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INTERACTIONS OF MARINE PROTECTED SPECIES WITH ARTISANAL FISHERIES IN THE PARQUE NATURAL DO SUDOESTE ALENTEJANO E COSTA VICENTINA (PNSACV) AND ADJACENT CLASSIFIED AREAS (SPAs AND SACs)

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ABSTRACT

The Natura 2000 Network is the world's largest coordinated network of protected areas. The PNSACV is part of the 168 protected sites established under the Natura 2000 Network in Portugal. Direct interactions between large marine vertebrates, such as sea turtles, cetaceans and seabirds and the world fisheries are very common and can be a serious threat to many populations. Interviews were conducted between September and December of 2018 to gather information on the fishing fleet operating in the park, the presence of marine protected species (MPS) and the eventual conflicts between the marine life and the fisheries. The majority of the fishers interviewed operating in the park reported to use bottom set nets (38.7%), the rest operated pots and traps (18.7%), longlines (16%) and purse seine (6.7%). From all the fishermen interviewed (n=75), one fifth (20%) reported to operate polyvalent boats. The most sighted species in the PNSACV were the bottlenose dolphin (*Tursiops truncatus*), the common dolphin (*Delphinus delphis*), the yellow-legged gull (*Larus michahellis*) and the northern gannet (*Morus bassanus*). All the fishermen interviewed reported to have some kind of interaction with the MPS studied, being the bottlenose dolphin (*Tursiops truncatus*), the common dolphin (*Delphinus delphis*) and the northern gannet (*Morus bassanus*) reported as the most interactive species. Although interactions do not seem to have a significant economic impact to the fishermen, some relevant bycatch events of some species in specific gears (e.g bottlenose dolphins and northern gannet in bottom set nets, common dolphins and yellow-legged gull in purse seine) were observed. This is a consequence of the obvious overlap between their distribution range and the more frequently used fishing grounds and arises some awareness on continuing efforts to monitor closely the impact of coastal fisheries on the mortality of marine protected species.

Key Words

Mainland Portugal; Marine Protected Area; PNSACV; Artisanal Fisheries; Interactions; Marine Protected Species; Cetaceans; Marine Birds; Marine turtles

RESUMO ALARGADO

As Áreas Marinhas Protegidas são uma das medidas de conservação mais importantes e eficazes aplicadas ao meio marinho. Estas áreas são estabelecidas pelo governo ou instituições na tentativa de criar um equilíbrio entre o ecossistema marinho e as atividades antropogénicas. A Rede Natura 2000 é a maior rede ecológica mundial de áreas protegidas. Criada pela União Europeia, esta Rede cobre certa de 18% do seu território terrestre e quase 9.5% do seu território marinho, e tem como objetivo a conservação de espécies e habitats considerados vulneráveis na Europa. O Parque Natural do Sudoeste Alentejano e Costa Vicentina (PNSACV) está incluído nas 168 áreas protegidas em Portugal classificadas sob a Rede Natura 2000. Localizado entre S. Torpes e Burgau, o PNSACV ocupa mais de 100km da costa Portuguesa, cobrindo cerca de 60 567ha de área terrestre e 28 858ha de área marinha. Apesar de área marinha protegida, a restrição à pesca é muito reduzida em praticamente toda a sua área, podendo por isso atividades pesqueiras dentro do parque afetar espécies marinhas protegidas tais como cetáceos, aves e tartarugas marinhas. As interações diretas entre espécies marinhas protegidas e a pesca são muito comuns mundialmente, podendo ter consequências negativas não só para as populações destas espécies, mas também para os pescadores em termos económicos com a perda de pescado e danificação de artes de pesca. Estas interações são mais comuns quando se operam artes que tenham como alvo espécies de peixes que façam parte da cadeia alimentar das espécies marinhas protegidas, uma vez que existe exploração do mesmo recurso por parte dos pescadores e dos animais marinhos.

O objetivo deste estudo, inserido no projeto MAR Sudoeste (MARSW), foi a avaliação de eventuais conflitos (interações) entre as artes de pesca artesanal e costeira operadas dentro do PNSACV e as espécies marinhas protegidas mais observadas (cetáceos, aves e tartarugas marinhas). Na ausência de dados de distribuição e abundância de cetáceos para a zona, dados de avistamento do golfinho comum (*Delphinus delphis*) e do roaz-corvineiro (*Tursiops truncatus*) foram gentilmente cedidos pela empresa de ecoturismo Mar Ilimitado de Sagres, para mapeamento de áreas de distribuição destas espécies. Foi assim também possível monitorizar as áreas de maior esforço de pesca e obter informação sobre sobreposição entre pescas e habitats de espécies marinhas protegidas, nomeadamente cetáceos.

Ao longo de quatro meses, de setembro a dezembro de 2018, foram feitas entrevistas (n=75) nos sete principais portos localizados no PNSACV, sendo estes os portos de Arrifana, Carrapateira, Sagres, Salema, Burgau, Lagos e Alvor. No total foram entrevistadas 17% da frota a operar no PNSACV. Os resultados mostram que a frota é maioritariamente uma frota costeira artesanal, com 38.7% dos entrevistados a operar redes, 18.7% a operar covos e armadilhas, 16% a operar palangre e 6.7% a operar cercadoras. Um quinto (20%) de todos os mestres entrevistados afirmaram operar barcos polivalentes, o que lhes permite operar mais do que um tipo de arte. As espécies mais avistadas pelos mestres na área de estudo foram o roaz-corvineiro (*Tursiops truncatus*), o golfinho comum (*Delphinus delphis*), a gaivota-de-patas-amarelas (*Larus michahellis*) e o ganso-patola ou alcatraz (*Morus bassanus*). O roaz-corvineiro, o golfinho comum e o ganso-patola foram as espécies apontadas pelos mestres como as que mais interagem com as embarcações. O roaz-corvineiro interage especialmente com redes fundeadas, por outro lado o golfinho comum está mais frequentemente associado com a pesca de cerco. O ganso-patola foi a espécie de ave marinha que revelou maior nível de interação, com captura acidental acessória especialmente em redes fundeadas. Apesar disso, as cercadoras foram a arte que apresentou um maior nível de captura acessória de espécies marinhas protegidas por saída, especialmente golfinhos comuns.

As interações entre pesca e espécies marinhas protegidas foram vistas pelos pescadores como pouco preocupantes, tendo a maioria expressado uma opinião neutra em relação à presença destas espécies nas suas áreas de pesca. No entanto, através da comparação dos mapas de áreas de pesca frequentadas pelos mestres entrevistados e os mapas de avistamentos de cetáceos feitos através dos dados cedidos pela empresa Mar Ilimitado, podemos ver que há uma sobreposição evidente das áreas frequentadas pelos mestres e pelas principais espécies de cetáceos que apresentaram interação. Isto pode vir a ser um problema no futuro com a escassez gradual de recursos e a consequente possibilidade de aumento destas interações. Assim, propõe-se a realização de mais inquéritos e recolha de mais informação sobre as interações da pesca artesanal com espécies marinhas protegidas, pois uma vez que a nossa amostra é relativamente pequena, não nos foi possível obter resultados estatisticamente significativos. Um maior número de entrevistas dar-nos-ia a hipótese de obter mais informação em termos de depredação, danificação de artes e captura acidental acessória o que nos daria a oportunidade de discutir medidas de gestão e conservação do meio marinho.

Palavras-chave:

Portugal continental; Áreas Marinhas Protegidas; PNSACV; Pesca Artesanal; Interações; Espécies Marinhas Protegidas; Cetáceos; Aves marinhas; Tartarugas marinhas

INDEX

INDEX OF FIGURES

INDEX OF TABLES

LIST OF ACRONYMS/ABBREVIATIONS

CBD – Convention on Biological Diversity
CFP – Common Fisheries Policy
CFP – Common Fisheries Policy
DGRM - Directorate-General of Natural Resources, Safety and Maritime Services
EEZ – Exclusive Economic Zones
EU – European Union
GLMs – Generalized Linear Models
IUCN – International Union for Conservation of Nature
IWC – International Whale Convention
MARSW – MAR Sudoeste
MPAs – Marine Protected Areas
MPS – Marine Protected Species
NA – Not Answered
SAC – Special Areas of Conservation
PNSACV – Parque Natural do Sudoeste Alentejano e Costa Vicentina
SCI – Sites of Community Importance
SD – Standard Deviation
SPAs – Special Protection Areas
UN – United Nations
UNEP-WCMC – UN Environment World Conservation Monitoring Centre

1. INTRODUCTION

1.1. Marine Protected Areas (MPAs)

Marine Protected Areas (MPAs) are one of the most important conservation measures applied to the marine ecosystem. These areas are established by governments or institutions and aim to improve conservation and fisheries management in an attempt to balance ecological constrains and anthropogenic activities (EEA, 2015; Batista & Cabral, 2016; Horta e Costa *et al.*, 2016). The International Union for Conservation of Nature (IUCN) defines protected areas as "*a clearly defined geographical space, recognized, dedicated and managed (…) to achieve the long-term conservation of nature with associated ecosystem services and cultural values*". There are various types of MPAs according to their stage of establishment and their level of protection (UNEP-WCMC *et al.*, 2018). The IUCN divides marine protected areas in six different categories (one of them with a subdivision) according to their management objectives:

Ia. Strict nature reserve: strictly protected areas with the objective of protecting biodiversity, where human visitation, use and impacts are limited;

Ib. Wilderness area: large unmodified or slightly modified areas without permanent or significant human habitation protected and managed to preserve their natural conditions;

II. National park: natural or near-natural areas created to protect large-scale ecological processes that provide a foundation for educational and recreational activities;

III. Natural monument or feature: areas created to protect a specific natural monument;

IV. Habitat/species management area: areas created to protect a particular habitat or species;

V. Protected landscape area or seascape: areas where the interaction between people and nature have produced a distinct character with high ecological, biological and cultural value and where the protection of the integrity of these interactions is vital to sustain the area;

VI. Protected areas with sustainable use of natural resources: areas with the objective of conserving natural ecosystems and assure the sustainability of the use of natural resources (Dudley, 2008; UNEP-WCMC, 2018).

These areas can also be classified by their level of protection and have zones with different types of protection. Horta e Costa *et al.* (2016) divided the levels of protection for the different zones within a marine protected area in 8 levels, being the level 1 the higher level of protection, called "*no-take zone*", and the level 8 the lowest level, which they called a site with "*unregulated extraction*" (Figure 1.1).

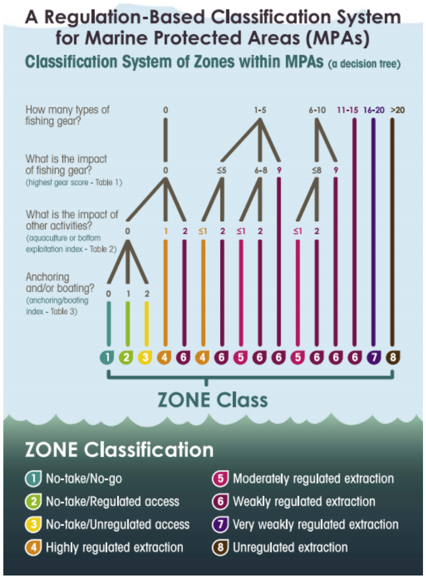


Figure 1.1 – Regulation based classification system for MPAs. Adapted from: Horta e Costa *et al.*, 2016.

Various studies have shown that, when well designed and actively managed, marine protected areas support the enhance of the abundance and size of species, the recovery of populations and communities, and preserve the structure of the habitats (Gill *et al.*, 2017; Horta e Costa *et al.*, 2016; Edgar *et al.*, 2014; Zupan *et al.*, 2018). To have a well-managed MPA it is important to include all stakeholders, including commercial and recreational fishermen, in the decision making, assuming a balance between a "*top-down*" and "*bottom-up*" approaches, this will lead to the development of solutions and management rules accepted by all parties, which will help the MPA reach its full potential (Bennett & Dearden, 2014; Edgar *et al.*, 2014; Gaymer *et al.*, 2014; Ferreira *et al.*, 2015).

1.1.1. MPAs in the world

Although a big part of the protected areas on earth are on land, the area covered by MPAs has increased continuously over the last five years, largely due to the designation of large MPAs in various parts of the world. The List of Marine Protected Areas, published by the UN Environment World Conservation Monitoring Centre (UNEP-WCMC) in July 2018, reported that over 6 million km^2 of the earth was covered by MPAs, representing 7.27% of the ocean. Areas under national jurisdiction, like the Exclusive Economic Zones (EEZ), have a higher percentage of protected areas (16.8%) in comparison with areas beyond national jurisdiction, with only 1.2% of the area being covered by MPAs (UNEP-WCMC *et al.*, 2018). There are 232 nearshore ecoregions, these are areas with a very homogenous species composition (Spalding *et al.*, 2007), around the world and 45.7% of those had, in July 2018, at least 10% of their area protected. That shows an increase of 9.5% since 2016. There has also been an increase in the protection of the high seas, yet 24.3% of the provinces still have less than 1% of the area protected. Although all regions of the planet have MPAs, there are regions (e.g. South America and Australia) that have very large reserves, whereas other regions (e.g. Europe) have a higher number of small MPAs (Figure 1.2) (UNEP-WCMC *et al.*, 2018).

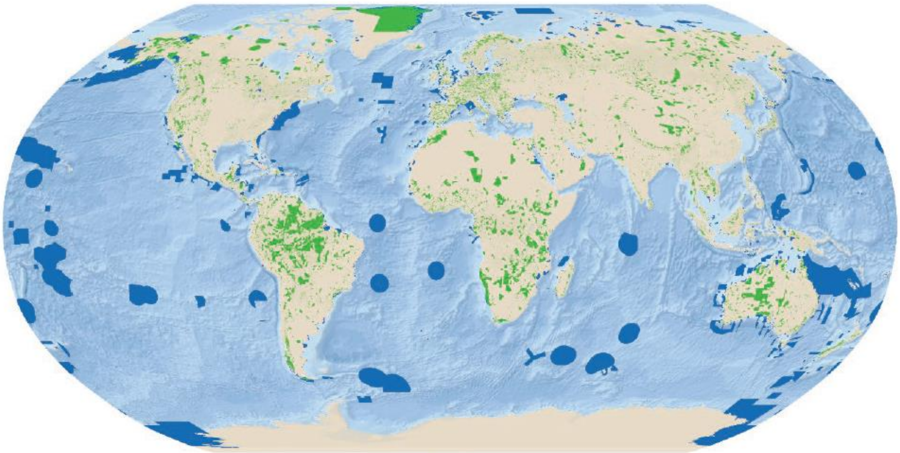


Figure 1.2- Spatial distribution of the world's terrestrial (green) and marine (blue) protected areas. Adapted from: UNEP-WCMC, 2018.

1.1.2. MPAs in Europe

Europe's sea covers an area larger that the continent itself, that is one of the motives why the European Union (EU) has acted on its responsibilities to preserve the health of its sea area by creating specific EU legislation and making progress towards reaching globally agreed targets to establishing MPAs such as the Aichi Target 11 under the Convention on Biological Diversity (CBD), that calls for at least 10% of coastal and marine areas conserved through MPAs by 2020 (Horta e Costa *et al.*, 2016; Gill *et al.*, 2017; EEA, 2018). Europe is one of the regions with the largest number of protected areas reported falling into the IUCN management categories. Most of these areas fall in the category IV, which means they were created to preserve and protect a particular habitat or species. Europe is also the region with the highest proportion of sites where no IUCN management category has been assigned (UNEP-WCMC, 2018).

Networks of MPAs operate at various scales and cover a range of protection levels, which work towards objectives that a single MPA cannot achieve. The Natura 2000 Network is the world's largest coordinated network of protected areas, covering over 18% of the European Union's land area and almost 9.5% of its marine territory. It aims to ensure the survival of Europe's most valuable and threatened species and habitats, listed under the Birds Directive and the Habitats Directive (European Commission, 2019; EEA, 2018; UNEP-WCMC, 2018). The Birds Directive aims to protect wild bird species that naturally occur in the EU. This Directive places great emphasis on the protection of habitats for endangered and migratory species, since habitat loss and degradation are the most serious threats that this species face. Within the Directive, the EU's member states select the most suitable sites based on scientific criteria and designate them as Special Protection Areas (SPAs). The Habitats Directive ensures the conservation of rare, threatened or endemic animal and plant species listed under the directive's annexes. The Commission, in agreement with the Member States, adopt a list of Sites of Community Importance (SCI) for each of the regions determined by the Habitats Directive. Once the list has been adopted, the Member States designate all these sites as Special Areas of Conservation (SAC) (Gaston *et al.*, 2008; European Commission, 2016; European Commission, 2017[1]; European Commission, 2017[2]).

The European sea has historically been divided as four separate regions including the Baltic Sea, the North-East Atlantic Ocean, the Mediterranean Sea and the Black Sea. The countries sharing each regional sea have set up Regional Sea Conventions (e.g. the OSPAR Convention in the North-Atlantic Ocean) to help combat the impacts of human activities and protect the marine biodiversity, this includes the development of networks of MPAs. Besides designating MPAs under the Natura 2000 network and in the context of the Regional Sea Conventions, the EU Member States also have the power to designate MPAs under national laws, if the sites are of interest. Some MPAs can be under national, regional and EU's protection laws (EEA, 2015).

1.1.3. MPAs in Portugal

Portugal had, in 2016, a total of 168 sites protected under the Natura 2000 network, 62 as SPAs and 106 as SCIs, which covered a total of 57 733km^2. From the 62 SPAs, 16 of them had a marine area that covered 8 747 km^2. When it comes to the SCIs, 31 of them also had a marine area that covered 24 101 km^2. This makes a total of 32 848km^2 of marine area covered (ICNF, 2016). Regarding MPAs under national law (not including the areas protected under the Natura 2000 network) there was, in 2016, a total of 71 areas that covered 6.4% of the area under national jurisdiction, 2.1% if we only consider the territorial waters and the EEZ together. A big part of Portugal's MPAs are located near the coast, just like most MPAs around the world, but recently an effort has been made to designate MPAs beyond 12nm, this will help to Aichi Target 11 under the Convention on Biological Diversity (CBD). Most MPAs in Portugal have a low level of protection, which means they allow human activities like fisheries without restriction. Only 0.1% of the territorial sea of the Azores and Mainland Portugal are classified has "*no-take zones*", meaning that the extractive activity in those areas is not allowed (Batista & Cabral, 2016; Horta e Costa, 2017).

1.2. The Portuguese fleet

Portugal has a wide coastal line and one of the biggest EEZs, composed by a continental shelf characterized by its high productivity (Vingada *et al.*, 2011). The Portuguese fisheries are managed in accordance with the Common Fisheries Policy (CFP), a set of rules set by the EU to manage the European fishing fleets and conserving fish stocks (European Commission, 2018). Depending on the fishing effort, the Portuguese fishing fleet can be classified as artisanal or industrial (Lewison *et al.*, 2004). The European Commission divided the Portuguese artisanal fleet operating in national waters into two categories: small-scale or local fleet, and large-scale or coastal fleet. This structure was adopted by the Directorate-General of Natural Resources, Safety and Maritime Services (DGRM) to publish their annual fisheries data (Gonçalves *et al.*, 2015; Oliveira *et al*, 2015; DGRM, 2018[1]).

The boats classified as local fleet have less than 9 meters in length and operate mostly fixed fishing gear like nets, longlines and pots and traps, in both inland waters and in open waters, having as target especially meso-pelagic and demersal species. These boats are frequently classified as polyvalent boats or multi gear boats, meaning that they are adapted to obtain licenses to operate with different types of gears. The choice of which gear is operated is decided by the skipper depending on the fish species to be targeted at a seasonal basis (Goetz *et al*., 2014[1]; Gonçalves *et al.*, 2015; Oliveira *et al*, 2015; DGRM, 2018[1]). There are two types of set nets operated by the Portuguese artisanal fleet: gillnets (Figure 1.3a) and trammel nets. Gillnets are composed by one single net, where the fish get entangled by their operculum, fins or even their body. Trammel nets are composed by three nets where the outer net has a larger mesh size. These rectangular nets are set in the water column with the help of ballasts and floats, to help them stay in a vertical position, and can be called drift or bottom nets, depending on the depth that they are set. This type of gear has as their target species demersal and semi-pelagic fish as well as cuttlefish. Longlines (Figure 1.3b) consist of a long line, called the main line, with several shorter lines with a baited hook attached to it. This kind of gear can be kept at various depths, depending if the target species is demersal or pelagic fish (Vingada *et al.*, 2011).

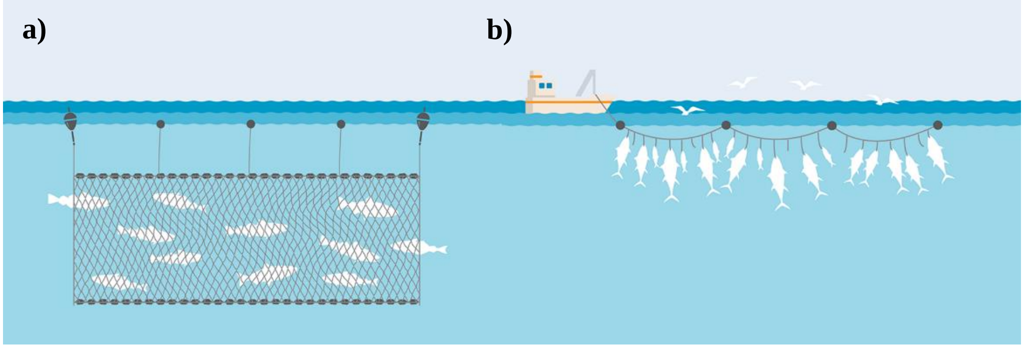


Figure 1.3- Gillnets (a) and longlines (b) illustration. Adapted from: Marine Stewardship Council in a) https://bit.ly/2Z79VX3 and b) https://bit.ly/2KUVWy.

Lastly, pots and traps (Figure 1.4a) are cage like structures designed to lure the animals into the structure and, once inside, make it difficult for the organisms to escape. These are normally used to catch octopus and occasionally bottom-dwelling fish (Vingada *et al.*, 2011).

Boats classified as part of the coastal fleet are larger than 9m and are either polyvalent (operating the same gears described above for local boats) or purse seiners (Figure 1.4b) having as their target species small pelagic fish who form dense schools like sardine (*Sardina pilchardus*), the Atlantic horse mackerel (*Trachurus trachurus*) and the Atlantic chub mackerel (*Scomber colias*). This gear consists of a vertical net, called seine, that is used to surround the school of fish. The bottom is then drawn together to enclose the fish preventing them from escaping. These boats have between 15 and 25 meters in length and operate in general in the first 12 nm from the coast, even though they are legally allowed to operate further away from the coast (Vingada *et al.*, 2011; Goetz *et al*., 2014[1]; Gonçalves *et al.*, 2015; Oliveira *et al*, 2015).

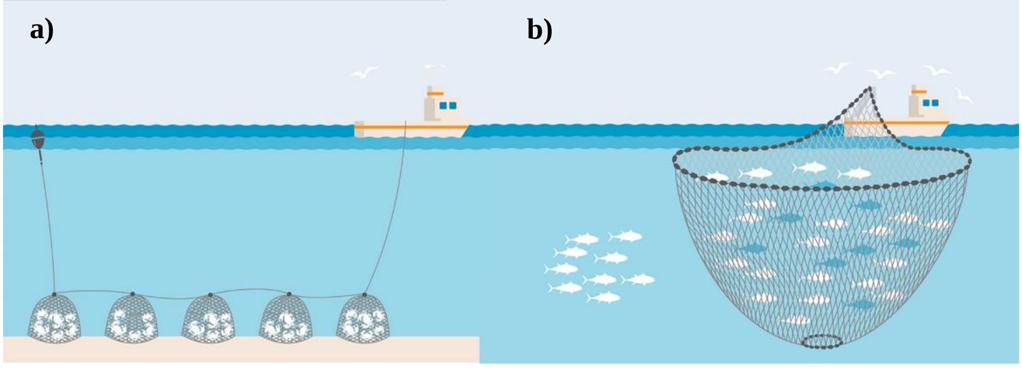


Figure 1.4- Pots and traps (a) and purse seine (b) illustration. Adapted from: Marine Stewardship Council in a) https://bit.ly/2H6YtVl and b) https://bit.ly/2Z9rWYZ.

In 2017, there were 45 fishing ports in Portugal with 7 922 vessels registered and 4 019 authorized to operate. The majority of the boats were smaller than 10m and operated nearshore, most of them being considered artisanal fishing. There was, in total, 17 642 fishermen registered by December 31st of 2017, 72.2% of them in polyvalent fishing, 10.8% in seine fishing, 9.4% in inland freshwaters and 7.6% in trawl fishing (Oliveira *et al.*, 2015; Prato *et al.*, 2016; INE, 2018).

In 2017 the mainland Portuguese fleet caught a total of 105 045 tons of fish that was valued in 213 241 thousands of Euros. The main species captured in order of weight were the Atlantic chub mackerel (*Scomber colias*), the Atlantic horse mackerel (*Trachurus trachurus*), sardine (*Sardina pilchardus*), the european anchovy (*Engraulis encrasicolus*) and the common octopus (*Octopus vulgaris*). In terms of value, the order of importance is: common octopus, followed by cuttlefish (*Sepia officinalis*), the european hake (*Merluccius merluccius*), the black scabbardfish (*Aphanopus carbo*) and the european conger (*Conger conger*), that were valued at an annual average of 6.52, 5.78, 3.27, 2.93 and 2.76 kg/€ respectively. In total, the fleet that reported more landings was the purse seine fleet, with a total of 45 489 ton of fish, followed by the polyvalent fleet (38 895 ton) and the trawl fleet (20 589 ton). Regarding the Algarve, the region in which is located the PNSACV, the fleet who reported more landings was the polyvalent fleet (5 006 ton) followed by the purse seine fleet (4 141 ton) and the trawl fleet (3 737 ton) (DGRM, 2018[2]).

1.3. Interactions Between Marine Protected Species (MPS) and Worldwide Fisheries

Over the last decades the anthropogenic pressure on the marine environment has increased significantly worldwide, making the chances of human and wildlife activity to overlap really high. Since there is an overlap between the main prey species of the top predators and the main target species of the fishermen and areas exploited, this will lead to a competition between fishermen and some marine species for the same resources. The effect of the fishing activities is one of the most detrimental anthropogenic impacts on the marine environment. The consequences of these activities are particularly evident in top predators that are affected by operational processes like incidental captures and collision with fishing vessels and by indirect ecological effects that induces changes in the marine food web. Fisheries can make certain areas more attractive to some species of predators by concentrating their prey species in a particular zone. This will turn certain habitats more favorable for feeding (e.g. some marine mammal species have been observed to feed in association with fisheries) and, as a result, increasing the probability of interactions between these predators and the gear (López, 2006; Goetz *et al.*, 2014[1]; Goetz *et al.*, 2014[2]; López *et al.*, 2019).

Direct interactions between large marine vertebrates, such as sea turtles, cetaceans and seabirds, most of which are protected worldwide, and the world fisheries can be a serious threat to many of their populations. Especial attention is given to groups that have slow reproductive rates like marine turtles and cetaceans. A direct interaction is assumed when the species comes into physical contact with the fishing gear. These interactions can lead to entanglement, resulting in adverse consequences for the animal like serious injury or even death (Lewison *et al.,* 2004; Revuelta, *et al.,* 2018). If the animal captured unintentionally is then discarded, the process is called bycatch, but if the animal is retained for consumption or sale, the process is referred to as nontarget catch (Read, 2008; Reeves *et al.,* 2013). Another aspect of MPS-fisheries interactions is the interference of these species in the fishermen's activity, which can negatively affect fisheries by resulting in loss of bait, fishing gear damage, decrease catches and depredation, where marine species remove or damage the fish captured in the gear (Revuelta *et al.,* 2018). These interactions were, for many years, related to industrial (offshore) fisheries. However, recent studies have shown that artisanal fisheries might also have a big impact on the marine coastal environment (Moore *et al.*, 2010). This type of interactions might lead to an increased probability of fishermen taking retaliatory measures against MPS, which can lead to a conservation issue that may have adverse consequences for several MPS populations (Hall *et al.*, 2000; Read, 2008).

MPS are most frequently caught unintentionally by the fishermen when they become accidentally entangled or hooked in fishing gear used to catch valuable target species. This type of interaction has been implicated as an important factor in the declining of many populations. Even though marine megafauna has a range of life-history strategies, they typically have a long lifespan, mature late in life, have low reproductive output and rely on an iteroparous reproductive strategy which requires high rates of adult survival. Bycatch of a few individuals from a sensitive age class can have large effects on the populations. This type of interaction has been implicated as a factor in the decline of many populations of MPS such as the Pacific loggerhead turtle (*Caretta caretta*), the leatherback turtle (*Dermochelys coriacea*) and the North Atlantic harbor porpoise (*Phocoena phocoena*) (Lewison *et al.*, 2004; Moore *et al.*, 2010; Reeves *et al.*, 2013). Although all gears have reported bycatch events, purse seiners, gillnets and pelagic trawls are the gears who cause a higher level of incidental mortality of cetaceans in European waters (Lewison *et al.* 2004; Hall *et al.* 2000). Sea turtles are usually caught by trawl, pelagic longline and coastal gillnet fisheries (Gilman *et al.*,2010). Seabirds are mostly caught by demersal and pelagic longline fisheries (Tasker *et al.*, 2000).

1.4. Interactions Between Marine Protected Species (MPS) and Portuguese Fisheries

In Portuguese continental waters, the accidental capture of MPS has been reported for most fisheries with the highest concerns towards bottom set nets and purse seining (Vingada *et al.*, 2011; Marçalo *et al.*, 2015). However, not many studies have been dedicated to the evaluation of interactions of MPS and Portuguese fisheries operating in the mainland. To date, the fishery most covered is purse seining and its interaction with cetaceans (Wise *et al.*, 2007; Marçalo *et al.*, 2015; Wise *et al.*, 2018), especially due to the common dolphin (*Delphinus delphis*) preference for sardine (*Sardina pilchardus*) as their favorite prey (Marçalo *et al.*, 2018). For marine birds there is only one work available (Oliveira et al. 2015) that evaluates bycatch levels in Portuguese fisheries, where the gears of most concern were bottom set nets, longlines and purse seining.

1.5. Legislation of Protection of Cetaceans, Marine Birds and Marine Turtles

Most large marine vertebrates are protected worldwide by national and international agreements and conventions like the International Whale Convention (IWC), BirdLife International and the Sea Turtle Conservancy, with their hunt only occurring in a few countries with a very controlled quota, with ethnical permission or illegally (which cannot be controlled). In Portugal all cetaceans are protected by international agreements and specifically by a national regulation, Decree-Law nº 263/81 of September 3rd. This law states that capture, transportation or sale (even when found already dead in the gear or stranded) is not allowed. This same regulation also states that, taking into account the decrease of some marine mammal populations in our coast, measures should be taken in order to protect and avoid incidental captures. Marine turtles are protected by various international agreements, and in Portugal, specifically in Madeira, by the Regional Legislative Decree nº 18/85/M of September 7th. When it comes to marine birds those are protected by the Natura 2000 Network by the Birds Directive that was transposed to the Decree-Law nº 140/99 of April 24th.

1.6. Aims

This study is part of the project MAR Sudoeste (MARSW), being directly related to two of the six objectives of the project that has as ultimate goal to develop an information and monitoring system on the marine biodiversity present in the PNSACV, which is classified by the Natura 2000 Network as a

SCI. This will allow to monitor the conservation status of the species and habitats present in the Natural Park (LPN, 2018). Therefore, this study aims to gather information on the presence of MPS on the PNSACV and the adjacent classified areas. It also intends to monitor the main fishing grounds attended by the fishermen operating within the park or its limits. Combining these two sources of information, we then analyze the eventual overlapping of these areas with the areas of occurrence of MPS, identifying areas most likely of conflicts between MPS and fisheries. For that we conducted interviews in the seven main fishing ports located inside the Natural Park, gathering information directly from the fishermen through individual questionnaires.

2. METHODOLOGY

2.1. Study area

The Sudoeste Alentejano and Costa Vicentina Natural Park (37º55'N, 9º00'W to 36º59'N, 8º40'W) is part of the 168 protected sites established under the Natura 2000 Network in Portugal. It covers over 100km of the Portuguese coastline between S. Torpes and Burgau and it extends 2 km into the Atlantic Ocean. Covering, in total, 60 567ha of land area and 28 858ha of maritime area. The Park was created in 1995, with the goal of protecting its natural and cultural values (Regulatory decree nº26/95, of September 21st; Resolution of the Council of Ministers nº 11-B/2011 of February 4th). The marine area of the park is characterized by a great diversity of coastal habitats including beaches, cliffs, islets and isolated rocks which make the perfect habitat for various unique species of fauna and flora. However, the park has a low level of physical protection, not having any restrictions in terms of fisheries (Resolution of the Council of Ministers nº 11-B/2011 of February 4th; ICNF, N.D.).

2.2. Data Collection

Face-to-face interviews were conducted between September and December of 2018 in seven of the most important ports of the study area (Arrifana, Carrapateira, Sagres, Salema, Burgau, Lagos and Alvor) to identify fishermen's perception of MPS and their interactions with their fishery. All the questionnaires (Appendix I) lasted approximately 15 minutes and took place in the harbors to maximize the number of interviews. Interviews were mainly performed while skippers were returning to the harbor to offload their daily catch or already at the harbor while they were mending their gears. All interviews were kept anonymous and we made sure to tell the interviewees that all the data would be treated as confidential. The study unit was the vessel, and there was an effort to interview only the skipper. To make sure we had an adequate sample size, we tried to interview at least 20% of the artisanal vessels in all the visited ports. The survey included clear concise questions designed to obtain reliable information about the interactions between fisheries and marine protected species (MPS). To obtain an overview of the MPS-fisheries interaction that could potentially suffer seasonal variations, we asked fishers to describe their general experience in the previous year. There was a map with every questionnaire (Appendix II) where fishermen could point their fishing grounds and an identification guide (Appendix III) with the main cetacean, marine bird and marine turtle species that occur in the region, so the fishermen could identify the frequently observed MPS in their fishing grounds.

Figure 2.1- Face-to-face interview being conducted in the port of Alvor.

The questions were divided in five main topics:

1. Sociodemographic questions: age, years of fishing activity, household and level of education;
2. Information on the type of fishing gear used as well as the main target species and spatial information about fishing grounds;
3. Fishermen's perception of MPS: what specie is more frequently sighted? What is the populations trend?;
4. Interactions between MPS and the fisheries: what fishing gear is more affected? Is there bycatch? Do MPS damage the gear? Can you provide an estimation of annual loss due to the interactions? What are the factors that influence the interactions?;
5. Mapping of main fishing grounds: where the fishermen pointed out the fishing grounds attended with the help of the map provided by the interviewer.

Common dolphin and common-bottlenose dolphin sightings data were obtained from whale watching vessels from the tour company Mar Ilimitado, operating from Sagres. In the absence of any other referenced information on the distribution and abundance of cetaceans for the area, this was an alternative method to obtain valuable data on cetaceans presence in the study area. Boat based surveys were conducted opportunistically by a trained observer, onboard of dolphin watching rigid inflatable boats (RIBs) departing from Sagres (SW mainland Portugal). The data was collected from January to December between 2015 and 2018, and ran up to 12nm from the shore covering an area of 650km^2. Surveys were conducted with the aim of maximizing cetacean sightings, searching on areas with optimal ocean conditions, and did not cover the study area homogenously. Alongside the geo-reference data for effort and sightings, the species, group size and composition, behavior and other categorical data were recorded (Sara Magalhães, pers. comm, September 2019). A similar surveying method was described in Silva *et al.*, 2014.

2.3. Data analysis

In order to simplify the analysis, the answers given by the fishermen were organized in a dataset in Excel where all the answers were divided by topics. Almost all the interviewees operated polyvalent or multi-gear boats, with the exception of those operating purse seiners. This means their boats may be licensed to fish with more than one gear, including longlines, bottom set nets and pots and traps. For the polyvalent fleet, this gives them the opportunity to adapt their boats and change the gear operated to exploit the periodicity of resources depending on season and availability (Borges *et al.*, 2001; Battaglia *et al.*, 2009). To simplify the statistical analysis, we considered only the gear more often used by each boat, unless stated otherwise.

All the plots and statistical analysis were made using R v3.5.1. Descriptive statistics, like the estimation of means and standard deviations (SD), was used for a primary analysis of the data collected during the interviews, allowing the examination of the artisanal fisheries characteristics and the perception of the interactions. Bycatch levels were calculated using an adaptation of the expression used by Oliveira *et al.* (2015):

$$l = \frac{b}{nt}$$

Where l is the bycatch level per gear, b is the total number of animals bycaught per year, n is the number of interviews done to the fishermen who operated that gear and t is the annual average of trips per boat. The value of the annual average trips per boat was used according to the fishermen's statements to all the gears, except purse seiners that are restricted by national law (Ordinance n.º 290/2018, of October 26th), only operating 6 months per year. The number of MPS bycaught per gear was calculated considering the principal gear used by each vessel. The numbers collected are representative of the animals bycaught in the study area in 2017/beginning of 2018.

Sunflower plots were used to allow us to see the distribution of our data. This kind of plot is composed by various short segments, called "*petals*", that radiate from a central point, called "*sunflower*". Each petal represents one observation, in this case, each petal represents one answer (Dupont and Plummer, 2003). When the explanatory variables were quantitative and continuous (e.g. age, years of work experience and depth of operation), generalized linear models (GLMs) were used to analyze their influence in the response variable such as species sighted and fishermen's opinion on the presence of MPS. GLMs are mathematical extensions of linear regression models suited to analyze ecological variables with non-Gaussian responses, like the distribution (presence-absence) of certain species in certain areas. These models are suited for ecological data, since it allows for non-normal distribution response variables as well as to some degree of nonlinearity on the response scale (Goetz, *et al.*, 2014[1]). When the explanatory variable was categorical (e.g. education level and gear operated), contingency tables and chi-square tests were used to determine their influence on the response variables, like the species who approach the boat more frequently and the fishermen's opinion on the presence of MPS. All response variables were binary, hence modelled in a regression with a binomial response. The fishermen's opinion on the presence of MPS was originally divided into three answers, "*negative*", "*neutral*" and "*positive*", but for analysis we recoded this as "*negative*" versus "*non-negative*", making it again suitable to a binomial regression.

The study area was divided into grid squares with a 1nmx1nm scale where the fishermen could point out the fishing grounds attended. Fishing grounds information registered during the interviews were entered into a geographical information system, Quantum GIS (QGIS 3.4.2.), to display the fishing grounds more frequently used as well as the fishing grounds where certain species were sighted and where bycatch was more frequent.

The dataset on common dolphin and bottlenose dolphin sightings kindly shared by the whale watching company Mar Ilimitado was analyzed and processed. To avoid bias a first analysis was made, using Microsoft Excel, to see if there were two sightings that could possibly be the same animal/group of animals. For that we compared the date, time and distance between each sighting, converting the coordinates (in degrees) into km, seeing as in latitude 1 degree = 110.574 km and in longitude 1 degree=111.325 cos(latitude)km (Fazackerley, 2019). We also took into account the swimming speed of each species, assuming that the common dolphins swims at a mean of 6.7±0.5 m/s and the bottlenoses swim at a mean of 6.2 ±0.7 m/s (Rohr *et al.*, 1998). Heatmaps were made for bottlenose and common dolphins with the previously processed data seen as these were the most recorded species in the area and also the species of interest for this study based on their interaction with set net and purse seine fisheries respectively. The heatmaps were then compared with the fishing ground maps to see if there was an area in which the presence of the common and bottlenose dolphins overlapped with the different fishing gears.

3. RESULTS

In this study, a total of 75 questionnaires (mean±SD= 10.7±7.6 interviews per port) were conducted in seven different ports in the PNSACV, covering around 17% of the fleet operating in the area. Interview coverage ranged from 10% to 78% of the artisanal vessels in each port (Table 3.1).

Table 3.1-Number of artisanal vessels registered in each fishing port, number of vessels interviewed in each port and percentage of vessels interviewed in each port. (*Source: European Commission, in: https://bit.ly/2lMLdh9).

Fishing Ports	Number Artisanal Vessels	Vessels Interviewed	% Vessels Interviewed
Arrifana	15	10	67
Carrapateira	5	2	40
Sagres	158*	18	11
Salema	9	7	78
Burgau	4	2	50
Lagos	217*	21	10
Alvor	24	15	63
TOTAL	432	75	17
AVERAGE	62	11	45

3.1.Sociodemographic Data

All fishermen interviewed were males between 26 and 74 years of age (mean±SD = 52.4±12.2; Figure 3.1) who had a mean of 32.4 years of work experience (SD=±14.6). From those interviewed, 96% (n=72) were skippers, the remaining 4% (n=3) were crew members. The majority (70.7%; n=53) reported to have family links to fisheries. Regarding education, 42.7% (n=32) of the fishermen interviewed reported to have completed the 1st cycle of education (6 to 9 years old), 29.3% (n=22) completed the 2nd cycle of education (10 to 11 years old), 16% (n=12) completed the 3rd cycle of education (12 to 14 years old), 8% (n=6) reported to have completed high school (15 to 17 years old) and 3 of the fishermen interviewed (4%) preferred not to answer this question (NA) (Figure 3.2).

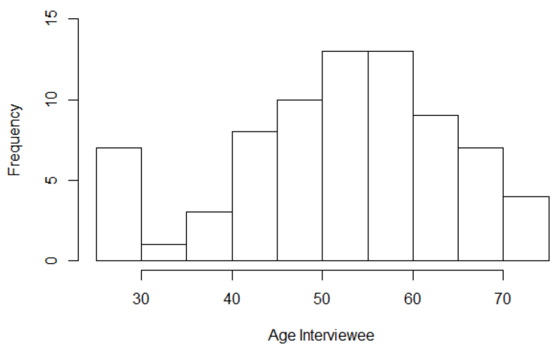


Figure 3.1- Frequency of the age of the fishermen interviewed.

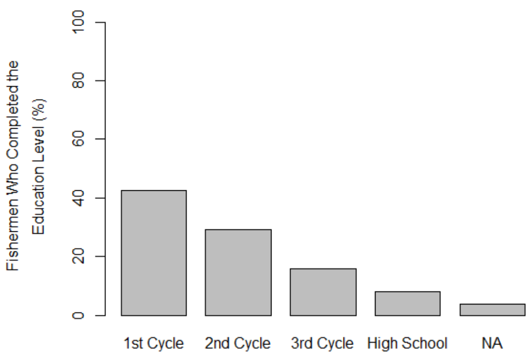


Figure 3.2- Education level of the fishermen interviewed.

To analyze the distribution of the fishermen's age in each level of education we used a boxplot (Figure 3.3), where we can verify that, in general, these two variables are inversely proportional, this means that older fishermen tend to have a lower level of education. Fishermen attending the 1st cycle of education were between 48 and 74 years of age, for those fishermen finishing the 2nd cycle of education ages ranged between 37 and 56 (in this category we verified the existence of two outliers corresponding to two young fishermen with 26 and 27 years old). Fishermen finishing the 3rd cycle of education had between 30 and 63 years of age, being this category the one who showed a larger amplitude of ages, and the age of the fishermen with the highest level of education ranged between 26 and 46 years old.

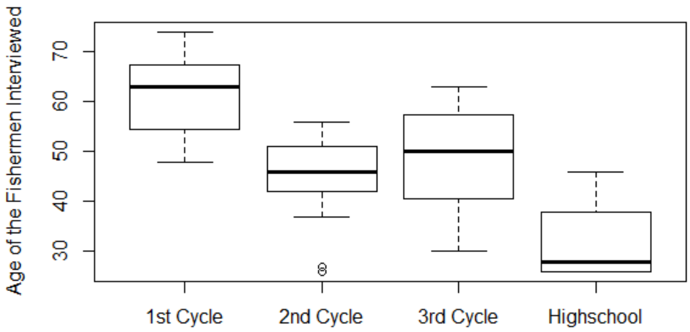


Figure 3.3- Boxplot showing the distribution of the age of the fishermen within each level of education.

3.2. Characteristics of The Sampled Fleet

3.2.1. Boat Description, Area and Depth of Operation

The mean boat size was 8.1±3.2m, ranging between 2.5m and 23m. The boats had a mean of 8.4ton (SD=±13.3ton), and the crew consisted of 1-8 fishermen (mean±SD = 2.4±1.6 fishermen). The fleet interviewed belongs to mainly local and coastal fisheries (Table 3.2) with only 4 boats fishing beyond 12 nautical miles from the coast. The minimum distance from the coast where the boats operated was 0.25nm and the maximum was 50nm. The time at sea and the depth of operation depended on the target species, but most vessels spent a mean of 8 hours at sea (SD=±2.6 hours) and operated at a mean depth of 55m (SD=±55.3m).

Table 3.2- Information of the boats of the fishermen interviewed (tonnage, HP, number of crew members, distance to coast in which they operate, depth of operation and hours spent at sea) separated into two categories: <9m and ≥9m.

Length	N	Ton		HP		Crew		Distance to Coast (nm)		Depth of Operation (m)		Hours at Sea	
		Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean
< 9 m	53	0.5 - 5.2	2.1	10 - 150	71.6	1 - 4	2	0.25 - 10	3.0	7 - 120	38.7	3 - 13	7.4
≥ 9m	22	4.0 - 63.0	20.7	16 -290	125	2 - 8	4	0.25 - 50	6.6	2 - 500	95.2	7 - 14	10

The map showing the fishing grounds used by the fishermen interviewed (Figure 3.4) confirms that the fleet interviewed operated mostly near the coast. The fishing grounds more frequently used in the South part of the Natural Park are the area between Sagres and Lagos, between 1 and 5 nm. The area between Lagos and Alvor was also very frequently attended by the fishermen, where they tend to operate between 1 and 6 nm. This goes in line with Sagres and Lagos being the ports with the largest fleets. In the West part of the study area the fishermen seem to not frequently fish beyond 3nm and tend to stay between Carrapateira and Arrifana.

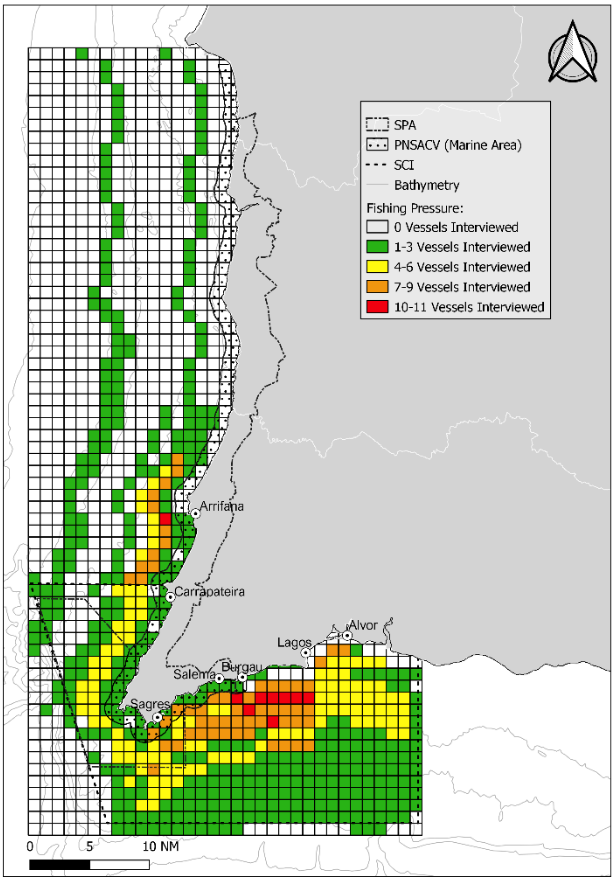


Figure 3.4- Fishing grounds attended by the fishermen interviewed.

Fishermen attend different fishing grounds depending on what gear they operate (Figure 3.5). Fishermen who operate longlines (Figure 3.5a) tend to fish further away from the coast, in comparison to other gears, having a slight preference in the area between Burgau and Portimão (located in the East border of the SCI). When operating nets (Figure 3.5b) the fishermen tend to stay between 1 and 5 nm, being the areas between Salema and Lagos and Carrapateira and Arrifana the grounds most attended. Fishermen who operate pots and traps (Figure 3.5c) set their gear scattered in the SCI showing a slight preference by the coastal area between Sagres and Salema. Meanwhile fishermen who operate purse seine (Figure 3.5d) tend to operate their gear near the coast throughout the natural park, not showing preference by any specific area.

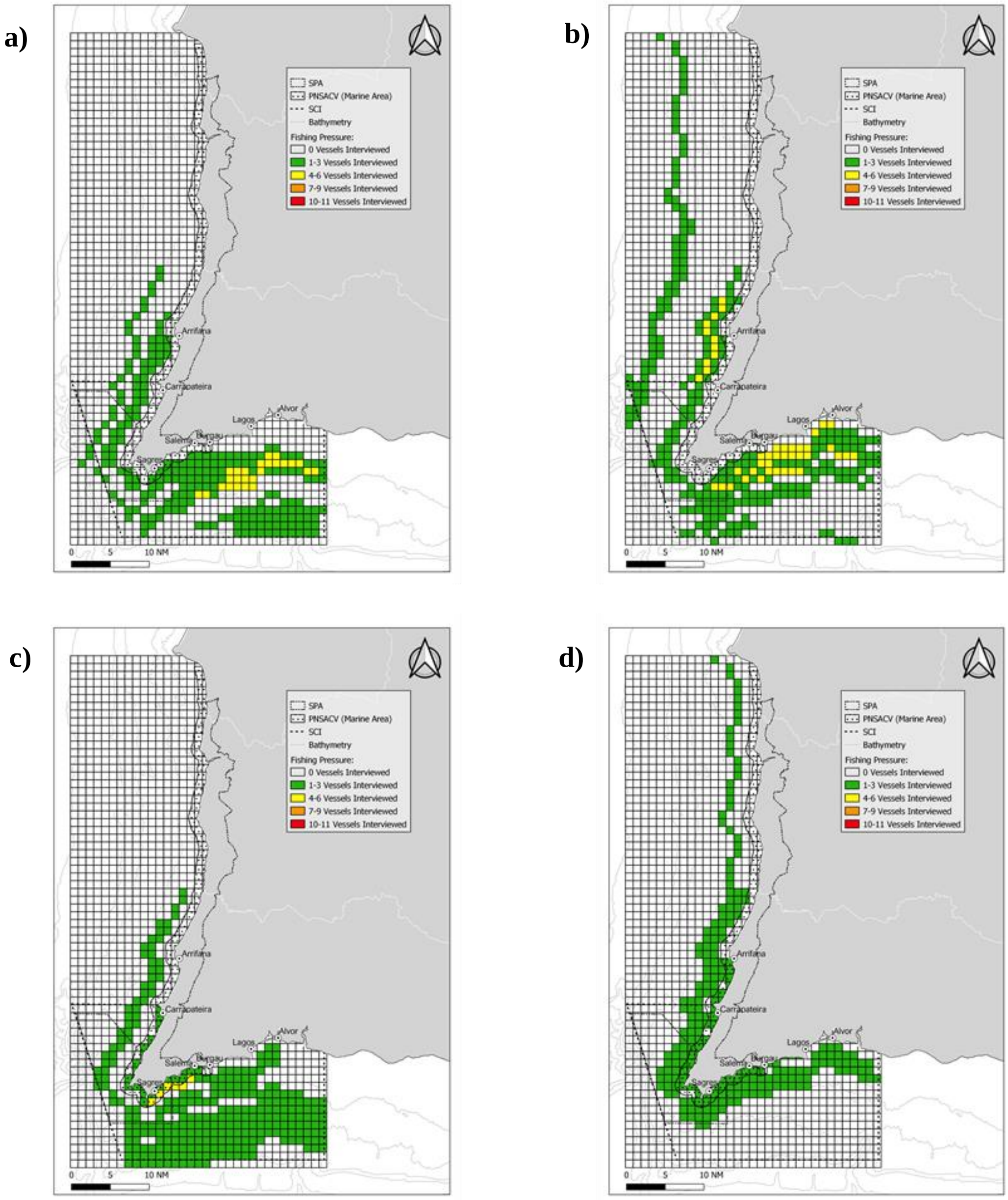


Figure 3.5 – Fishing grounds attended by the fishermen when operating: a) longlines; b) bottom set nets; c) pots and traps; and d) purse seine.

3.2.2. Fishing Gear Most Frequently Used

Most skippers approached, except those operating purse seiners, operate polyvalent vessels, meaning that all hold licenses for more than one type of gear. The fishing gear most frequently used were bottom set nets (38.7%; n=29 boats), which include gill and trammel nets, followed by pots and traps (18.7%; n=14 boats), longlines (16%; n=12 boats) and purse seine (6.7%; n=5 boats) (Figure 3.6). From all the fishermen interviewed, 20% (n=15) operated more than one type of gear (n=8 fishermen, used a combination of pots and traps and longlines; n=4 fishermen used a combination of nets and pots and traps; n=2 fishermen used a combination of nets, longlines and pots and traps; and n=1 fisherman, used a combination of longlines and purse seine – Figure 3.7).

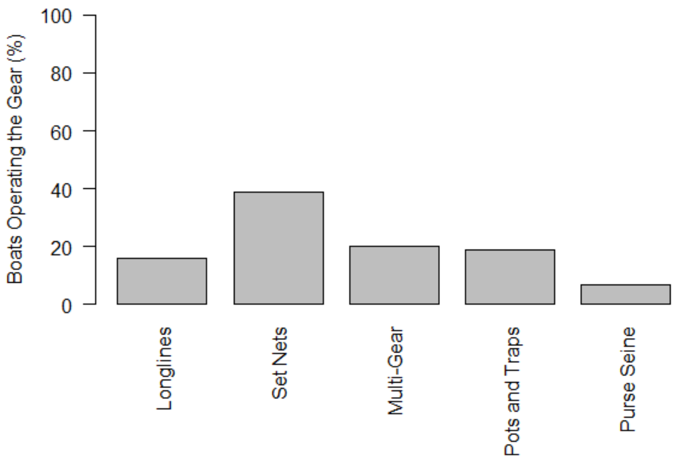


Figure 3.6- Barplot showing the gears operated by the fishermen interviewed.

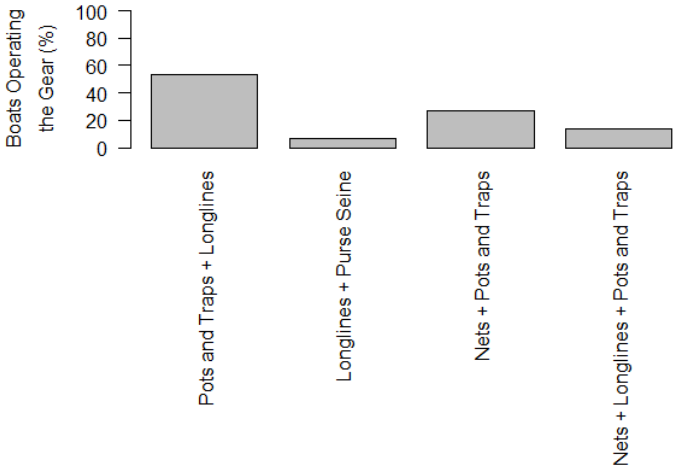


Figure 3.7- Barplot showing the combination of gears operated by the multi-gear boats.

The fishing gear most frequently used in the fishing ports of Arrifana (n=10), Sagres (n=18) and Lagos (n=21) were bottom set nets, and longlines were the gear more used in the fishing ports of Alvor (n=15) and Carrapateira (n=2). Boats in Salema (n=7) and Burgau (n=2) were operated mostly with pots and traps (Table 3.3).

Table 3.3- Number of vessels interviewed by port and gear operated.

Fishing Ports	Longlines	Pots and Traps	Purse Seine	Nets	Polyvalent	TOTAL
Arrifana	1	2	0	4	3	10
Carrapateira	1	0	0	0	1	2
Sagres	2	3	2	10	1	18
Salema	0	4	0	1	2	7
Burgau	0	1	0	0	1	2
Lagos	0	3	3	14	1	21
Alvor	8	1	0	0	6	15
TOTAL	12	14	5	29	15	75

The gill and trammel nets used by the fishermen had a mean of 2374.7m (SD=±1880.9m) in length and a mean of 2.4m (SD=±1.1m) in height. Purse seine nets had a mean of 333.3m (SD=±218.3m) in length and 56.3m (SD=±39.4m) in height. The longlines operated had a mean of 3599m (SD=±1515.1m) in length and supported a mean of 1925 hooks (SD=±1319 hooks). The fishermen who used pots and traps reported to use a mean of 528.5 pots and traps (SD=±392.2 pots and traps) per gear with a mean length of 1104m (SD=±1664.3m).

3.3. Sightings and Fishermen's Attitude Towards Marine Protected Species (MPS)

3.3.1. Species Most Frequently Sighted

Regarding the presence of MPS in the fishing grounds, 98.7% (n=74) of the fishermen interviewed reported frequently encounters with cetaceans, 96% (n=72) reported frequently encounters with bird species, while only 5.3% (n=4 fisherman) reported to frequently sight marine turtles.

Interviewed fishermen were able to identify the species sighted by experience and with the help of an identification sheet. In general, the bottlenose dolphin (*Tursiops truncatus)* was the most frequently species of cetacean sighted, reported by 61 fishermen (81.3%) followed by the short-beaked common dolphin (*Delphinus delphis*), reported by 58 fishermen (77.3%). Other cetaceans such as harbor porpoises (*Phocoena phocoena*), Risso's dolphins (*Grampus griseus*), northern minke whales (*Balaenoptera acutorustrata*) and killer whales (*Orcinus orca*) were also reported by some fishermen but as species rarely sighted.

Regarding marine birds, the yellow-legged gull (*Larus michahellis)* was the most frequently sighted species, reported by 63 fishermen (84%), followed by the northern gannet (*Morus bassanus*) reported by 47 fishermen (62.7%). *Puffinus* sp., the scopoli's shearwater (*Calonectris diomedea)* and the great cormorant (*Phalacrocorax carbo*) were also mentioned by some fishermen, but rarely sighted.

When it comes to marine turtles, they are rarely sighted. The only species reported as frequently sighted was the loggerhead sea turtle (*Caretta caretta*), although only three fishermen said to have frequently encounters with these species. The leatherback sea turtle (*Dermochelys coriacea*) was also mentioned by some fishermen (13.3%, n=10), but as a species that was rarely sighted.

3.3.2. Factors That Might Influence the Sightings

The sighting of different MPS can be influenced by many factors such as the fishing grounds where the boats operate, the depth of operation and even the gear operated and the target species.

3.3.2.1. Fishing Grounds (Area) and Depth of Operation

Different MPS frequent different fishing grounds. Bottlenose dolphins were sighted in almost the whole area designed as SCI (Figure 3.8a). Bottlenoses were sighted by a higher number of fishermen in the areas between Carrapateira and Arrifana (West coast) and Sagres and Alvor (South coast). Common dolphins were also spotted on most of the study area (Figure 3.8b), on the South coast the specie was seen by a higher number of fishermen closer to the coast and mainly between Sagres and Lagos, meanwhile on the West part of the study area, this species was seen further away from the coast, when in comparison with the bottlenoses.

a) b)

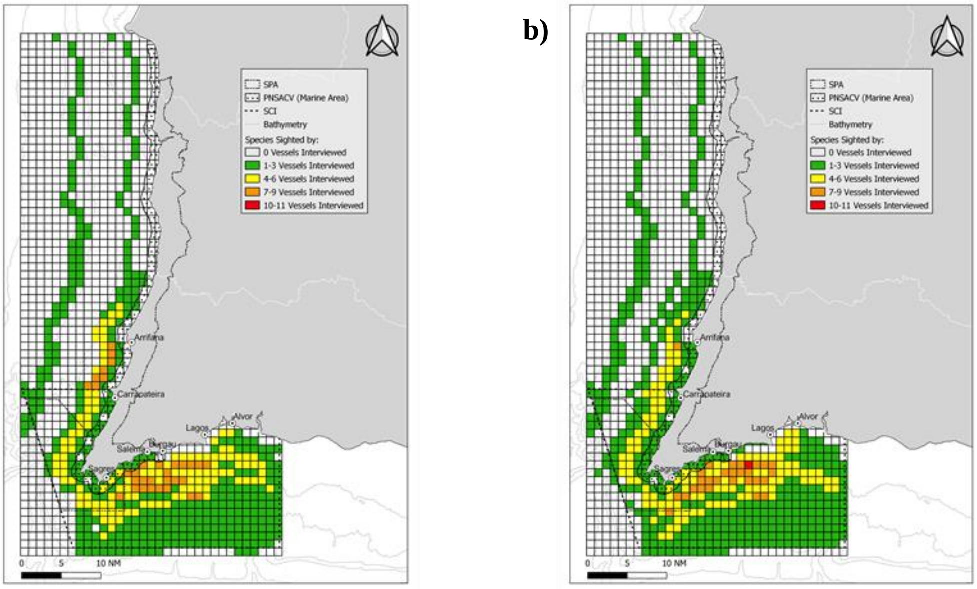


Figure 3.8- Fishing grounds attended by the fishermen who reported to sight a) bottlenose dolphins (*Tursiops truncatus*) and b) common dolphins *(Delphinus delphis).*

When it comes to marine bird species (Figure 3.9) there is, in general, a high number of fishermen reporting the sighting of this group of animals on the West part of the study area, mainly between Carrapateira and Arrifana. The yellow-legged gull (Figure 3.9a) and the northern gannet (Figure 3.9b) are the bird species more frequently reported in the South area of the SCI, being reported by a lot of fishermen who operated their gear up to 8nm away from the coast. *Puffinus* sp. (Figure 3.9c) was only reported by the fishermen who operated closer to the coast, not being reported by the fishermen who operated beyond 6 nm. The fishing grounds attended by the fishermen who reported to sight Scopoli's shearwaters do not have a clear pattern (Figure 3.9d), this specie was sighted throughout the study area from Portimão to Odemira, up to 12 nm away from the coast. Great cormorants were sighted by the fishermen who operated closer to the coast, up to 4 nm away from the coast (Figure 3.9e).

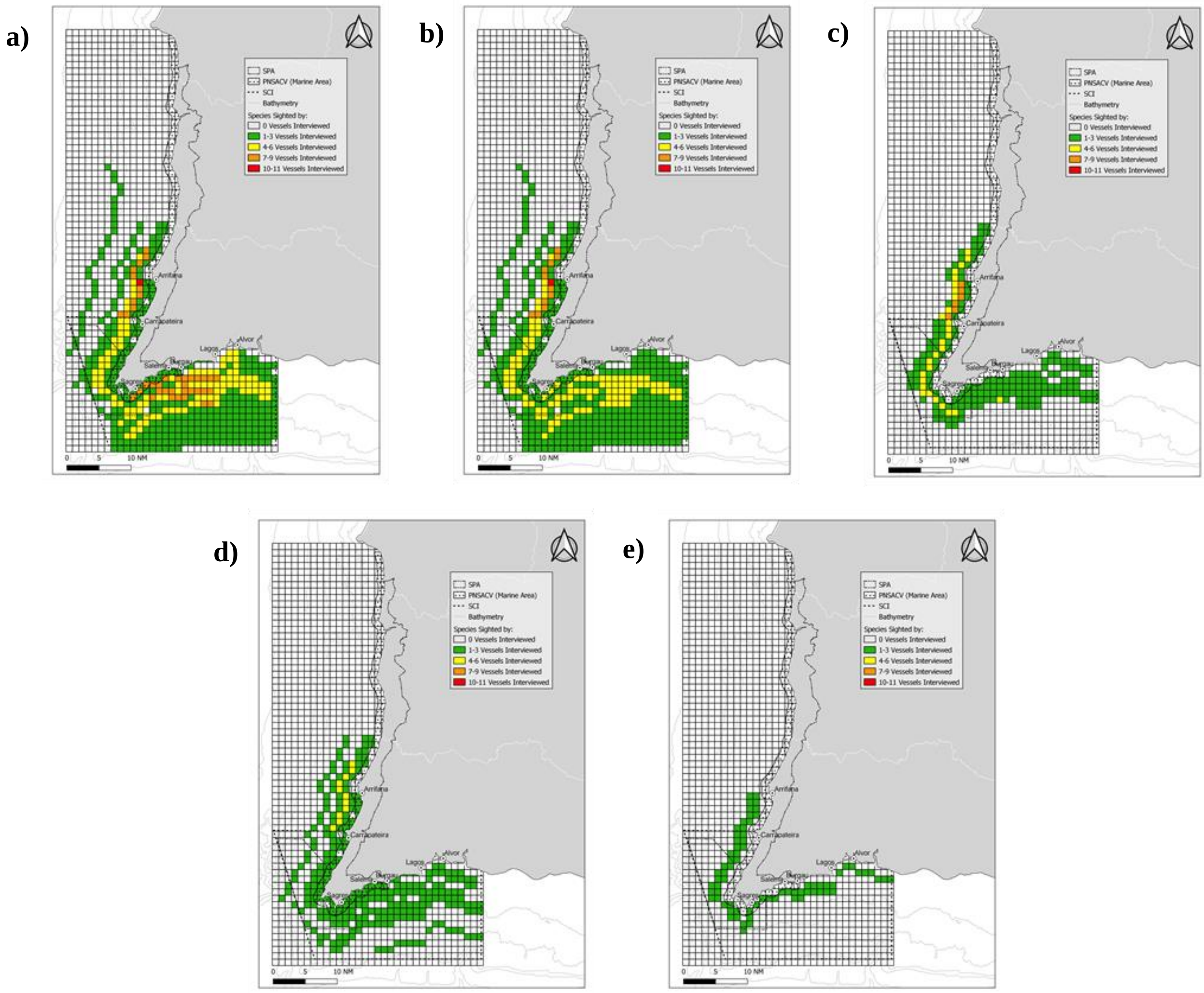


Figure 3.9- Fishing grounds attended by the fishermen who reported to sight a) yellow-legged gulls (*Larus michahellis*); b) northern gannets (*Morus bassanus*); c) *Puffinus* sp.; d) Scopoli's shearwater (*Calonectris diomedea*); and e) great cormorants (*Phalacrocorax carbo*).

Sea turtles were rarely reported by the fishermen (Figure 3.10), the only three fishermen who reported to sight individuals of the species *Caretta caretta* operated in both the South and the West part of the study area and operated up to 10 nm away from the coast.

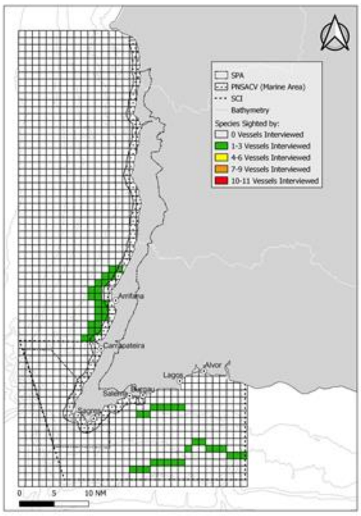


Figure 3.10- Fishing grounds attended by the fishermen who reported to sight loggerhead sea turtle (*Caretta caretta*).

Regarding the influence that depth of operation might have on the sight of certain species, we can see that, in general, the fishermen who operated their gear at less than 50m deep sighted a bigger variety of MPS in comparison with the fishermen who operated their gear deeper (Figure 3.11).

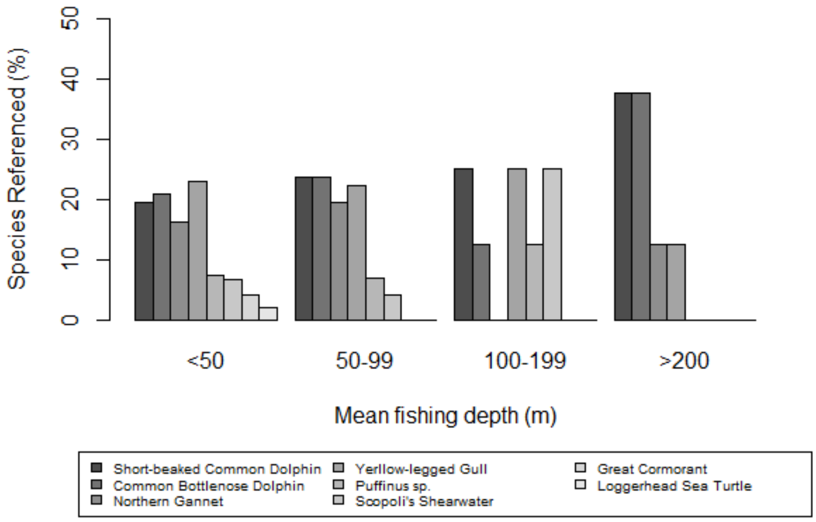


Figure 3.11- Percentage of MPS referred by the fishermen as frequently sighted by depth of operation.

Statistically the Generalized Linear Models (GLMs) indicated that the depth of operation is non-significant ($p>0.05$) in every species (Table 3.4). However, the trend has a slight positive influence on the sighting of cetaceans, meaning that the fishermen have a better chance of spotting these species if they operate their gear deeper. As for all other species this factor shows the opposite trend.

Table 3.4- GLM results. All response variables follow a binomial distribution, related to presence/absence of the animals in the fishing grounds. Estimates, standard errors (SE) and P-values were used to see if the explanatory variable (depth of operation) had any effect on the response variable (presence of the species on the fishing grounds).

Response Variable	Explanatory Variable	Estimate	SE	P-value
Common Dolphin	Depth of Operation	0.0187	0.0154	0.226
Bottlenose Dolphin	Depth of Operation	0.0045	0.0082	0.584
Northern Gannet	Depth of Operation	-0.0060	0.0053	0.260
Yellow-Legged Gull	Depth of Operation	-0.0095	0.0055	0.082
Puffinus sp.	Depth of Operation	-0.0055	0.0074	0.460
Scopoli's Shearwater	Depth of Operation	-0.0063	0.0089	0.460
Great Cormorant	Depth of Operation	-0.0603	0.0379	0.111
Loggerhead Sea Turtle	Depth of Operation	-0.0591	0.0526	0.261

3.3.2.2.Gear and Target Species

The gear is normally chosen depending on the target species to be captured. Figure 3.12 reflects the most captured species for each gear used. Namely, purse seining (Figure 3.12a) targets small pelagic fish, mainly sardine (*Sardina pilchardus)* and chub mackerel (*Scomber colias*); pots and traps (Figure 3.12b) captures mostly octopus (*Octopus vulgaris*), followed by conger eel (*Conger conger*) and moray eels (*Muraena helena*); bottom set nets (gill and trammel nets) caught a big variety of fish with 17 species in total reported by the fishermen such as red mullet (*Mullus barbatus*), blackspot seabream (*Pagellus bogaraveo*) and thickback sole (*Microchirus variegatus*) referred as the three species most frequently caught (Figure 3.12c). Figure 3.12d shows that longlines target mostly 11 fish species, with the blackspot seabream (*Pagellus bogaraveo*), the white seabream (*Diplodus* sp.) and the common pandora (*Pagellus erythrinus*) as the most frequently caught.

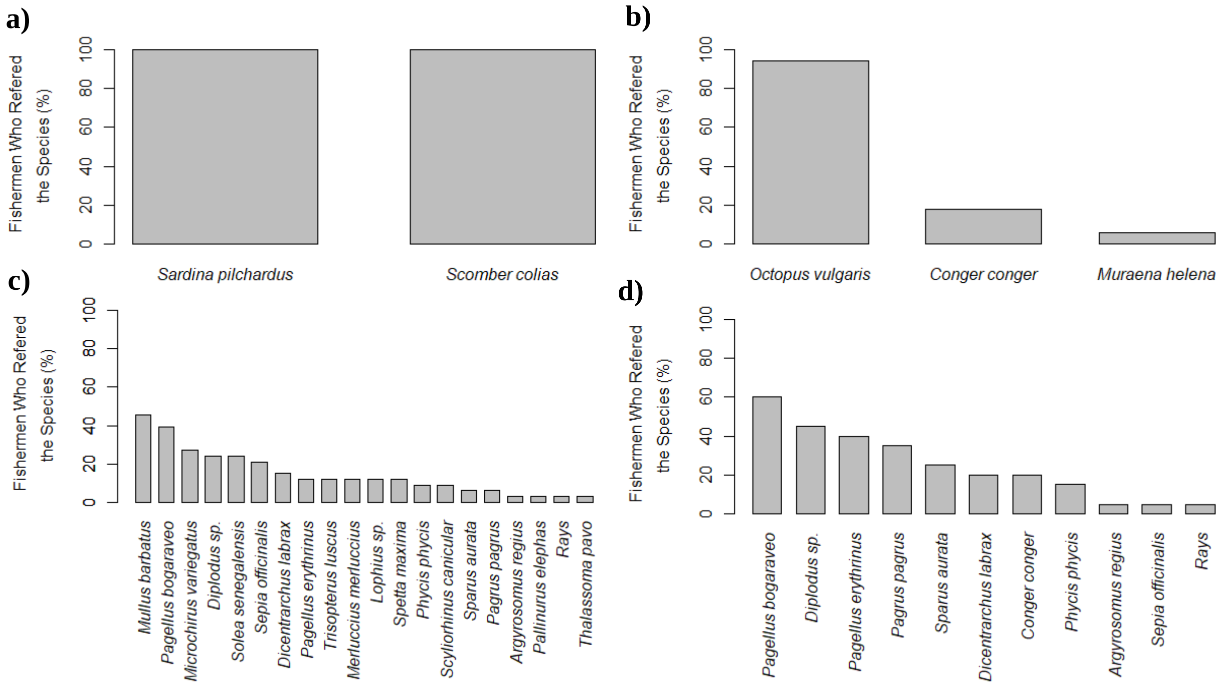


Figure 3.12- Fish species most frequently caught while operating: a) purse seine; b) pots and traps; c) bottom set nets; and d) longlines.

3.3.3. Fishermen's Point of View

Opinion regarding the presence of MPS is related with disturbances or interferences with the fishing practices. Thus, from all the fishermen interviewed, most (70.7%; n=53) reported they were indifferent (neutral) to the presence of the MPS. On the contrary, 20% (n=15) reported that the presence of these species was negative, justifying their opinion by saying MPS could cause additional costs by damaging the nets and the capture and that these species consumed many fish in the sea and would sometimes scare the target species. The remaining 9.3% (n=7) said that the presence of these animals was positive justifying it by saying the cetaceans helped to join and detect the fish and acted as welcome company (Figure 3.13).

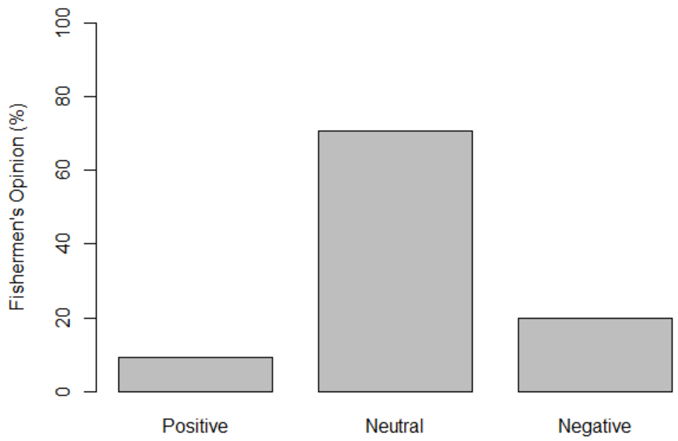


Figure 3.13- Fishermen's opinion on the presence of MPS.

3.3.3.1. Influence of The Gear Operated and Sociodemographic Data in The Fishermen's Opinion on The Presence Of MPS

Figure 3.14 shows that fishermen who operate bottom set nets (gill and trammel nets) had a more negative opinion on the presence of MPS when in comparison to the fishermen who operated other kinds of gear. This goes in line with some MPS causing extra economic loss to the fishermen of bottom set nets in particular.

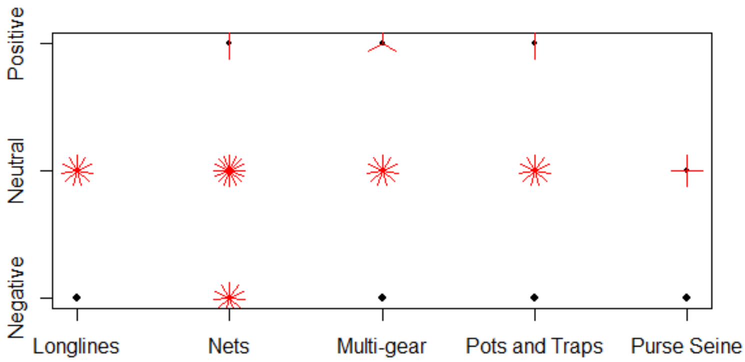


Figure 3.14- Sunflower plot showing the relation between the gear operated by the fishermen and their opinion on the presence of MPS. Each tick represents a positive reply for the corresponding combination of fishing gear and fisherman opinion.

Sociodemographic data such as age, education level and years of work experience might have an influence on the opinion of the fishermen on the presence of the MPS (Figure 3.15). Figure 3.15a shows that there is not a clear tendency with age, with most fishermen having a neutral opinion on the presence of MPS. Analyzing the sunflower plot showing the relation between the level of education and the fishermen's opinion (Figure 3.15b), we can see that there is a tendency for the fishermen who have a lower education to show a more negative opinion on the presence of the MPS studied (three of the fishermen interviewed did not answer the question about the education level, those are not represented in the plot). Figure 3.15c shows the relation between the fishermen's work experience and their opinion on the presence of MPS, we can see that the fishermen who have less work experience, also coinciding with being younger, tend to show a more positive opinion on the presence of these animals, although there is not a clear tendency between the two variables (two of the fishermen interviewed did not answer the question regarding their work experience and those are not represented in the plot).

In general, we can conclude that, from the sociodemographic data, the education level shows a clearer influence on the opinion of the fishermen. The fishermen who have a higher level of education, and thus a more positive opinion on the presence of MPS, are also the ones who are younger and have less work experience.

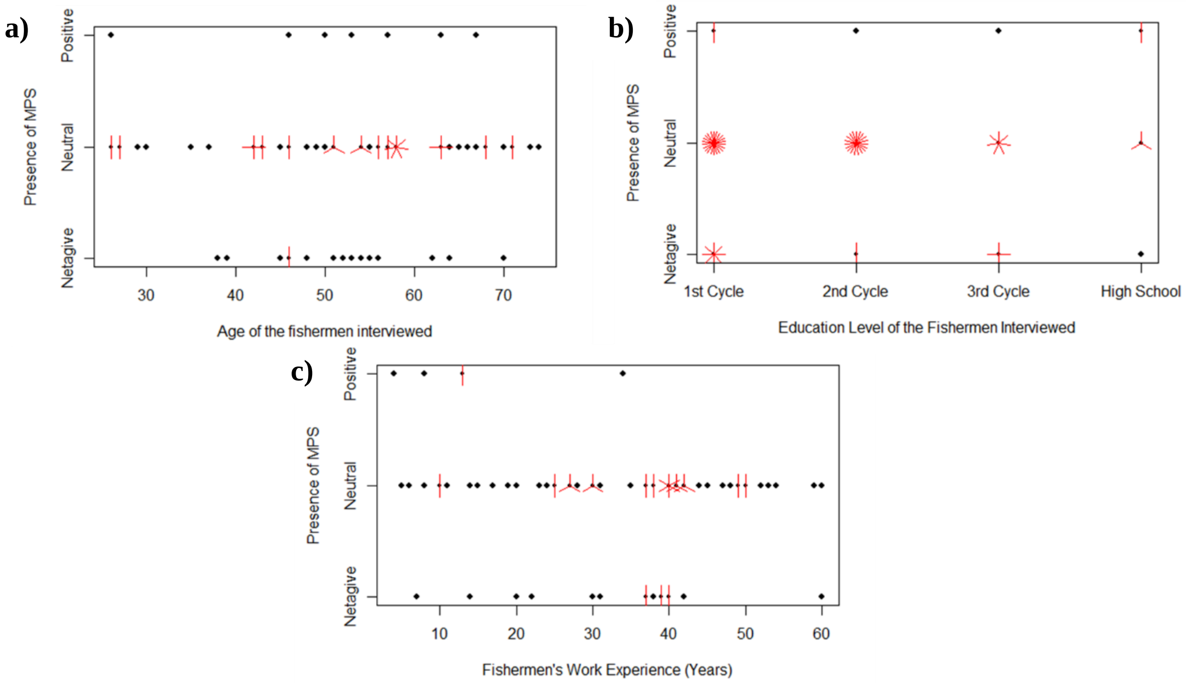


Figure 3.15- Sunflower plots showing the relation between: a) the age of the fishermen interviewed and their opinion on the presence of MPS; b) the education level of the fishermen interviewed and their opinion on the presence of MPS and c) years of work experience of the fishermen interviewed and their opinion on the presence of MPS. Each tick represents a positive reply for the corresponding combination of a) age and fisherman opinion; b) education level and fisherman opinion and c) work experience and fisherman opinion. Each tick represents a positive reply for the corresponding combination of the different factors and the fisherman opinion

The GLMs (Table 3.5) indicated that the age of the fishermen interviewed has a slight positive influence on the opinion of the fishermen on the presence of the MPS on their fishing grounds. Regarding the fishermen's years of work experience, this variable has a slight negative influence on the fishermen's opinion on this subject, this goes in line with the sunflower plot above (Figure 3.15c) that shows that fishermen with less work experience tend to have a more positive opinion on the presence of MPS on their fishing grounds. Regarding the coefficient of these two variables, this value is non-significant ($p>0.05$).

Table 3.4- GLM results. All response variables follow a binomial distribution, related to presence of the animals in the fishing grounds, fishermen's answers were divided by positive + neutral and negative for the making of this test. Estimates, standard errors (SE) and P-values were used to see if the explanatory variable had any effect on the response variable.

Response Variable	Explanatory Variable	Estimate	SE	P-value
Fishermen's Opinion	Age	0.0197	0.0438	0.653
Fishermen's Opinion	Work Experience	-0.0179	0.0375	0.634

The chi-square test ($\chi^2(3)=3.3761$; $p= 0.3372$) indicated that the level of education and the opinion of the fishermen are independent variables, meaning that the education level does not have an influence on the fishermen's opinion.

3.3.3.2.MPS Abundance and Environmental Factors That Might Influence the Sightings

Regarding the perception of the cetacean population abundance in the fishing grounds for the last 5 years, 85.3% (n=64) of the fishermen interviewed reported that the population increased in the last 5 years, 8% (n=6) reported that the population has been stable, 4.0% (n=3) reported a decrease, and the last 2.7% (n=2) reported they were not aware of the population trend (Figure 3.16).

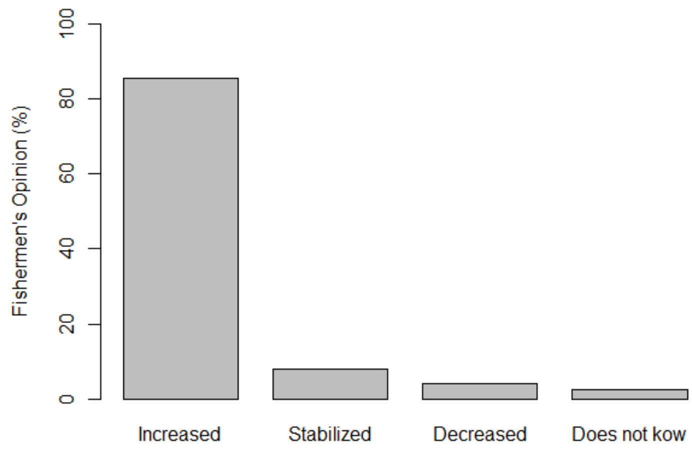


Figure 3.16- Fishermen's perception of the abundance of the cetaceans population in the last five years.

Concerning which factors influence the sighting of the MPS (Figure 3.17), month/season of the year was the most referred one, indicated by 77.3% of the fishermen interviewed (n=58). When asked in which season there was a higher chance of sighting MPS, most of them (73.3%; n=55) answered Summer. The second factor that, in the fishermen's opinion, influences the sighting of the MPS is the target species, with 56% of the fishermen interviewed (n=42) pointing this factor out and saying that fishermen that had small pelagic fish and cuttlefish (*Sepia officinalis*) as their target species had a higher chance to sight and have interaction with species like the short beaked common dolphin and the bottlenose dolphin, respectively. The time of day was referred by 38.7% of the fishermen (n=29) as a factor that also influenced the sighting of MPS, pointing out the sunrise and sunset the time of day where it was most likely to spot these species. The weather and sea conditions were referred by 26.7% of the fishermen interviewed (n=20) as a factor that could influence the sighting of the MPS, with some fishermen adding that there was a higher probability of spotting these species when there were good sea conditions. Some fishermen (24%, n=18) pointed out the fishing operation, i.e. if they were hauling navigating vs. net setting, as a factor that could also influence the sighting of the MPS; 17.3% (n=13) said that there were fishing grounds where there was a higher probability of sighting MPS; 5.3% (n=4) said that the fishing gear operated could influence the sightings and 1.3% (n=1) pointed out that, when using nets, the mesh size could influence the sighting of the MPS and that the depth of operation could also be an influencing factor. There were some fishermen (12%, n=9) that reported that none of the factors referred above could influence the sighting of the MPS, suggesting that no environmental factor could increase or decrease the probability of spotting MPS.

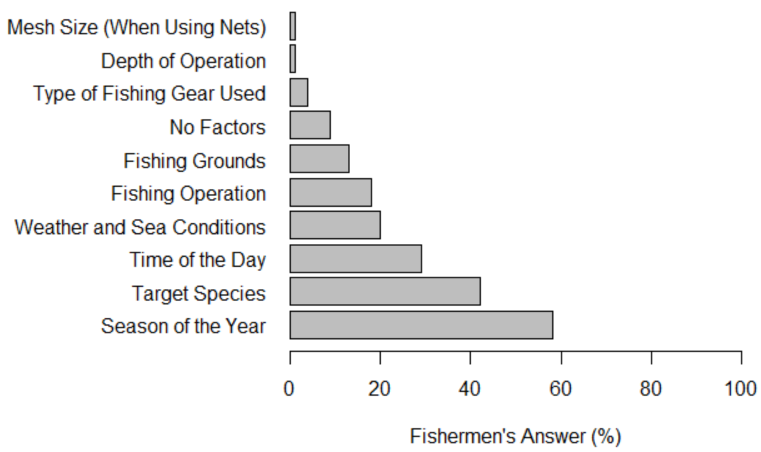


Figure 3.17- Barplot showing the environmental factors that, in the fishermen's opinion, influence the sighting of MPS.

3.4. Interactions

3.4.1. Frequency of Interactions and Approach Operation

When asked about the frequency of interactions between their gear and the MPS in the last five years, most fishermen (54.7%, n=41) reported that the interactions have increased, 29 fishermen (40.3%) reported that the frequency of the interactions is the same and only 2 fishermen (2.7%) reported a decrease (Figure 3.18).

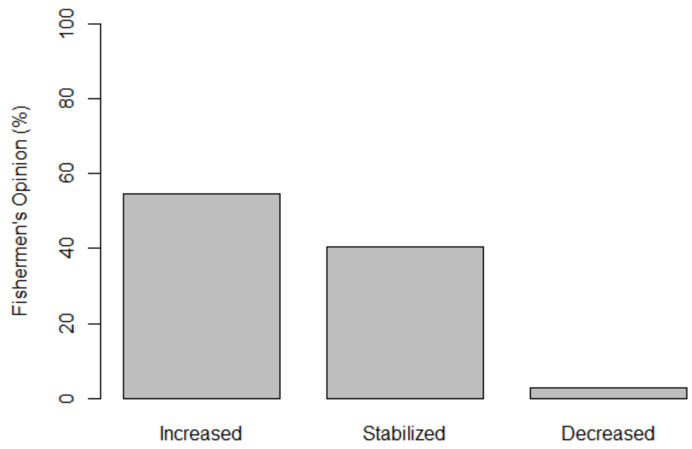


Figure 3.18-Fishermen's perception of the frequency of interactions in the last five years.

Almost all fishermen interviewed (85.3%; n=64), reported that cetaceans approached the boat more frequently when they were navigating, followed by when they are hauling (44%; n=33), only 7 fishermen (9.3%) reported to be approached by the MPS when they were net setting, and one did not answer (NA) (Figure 3.19).

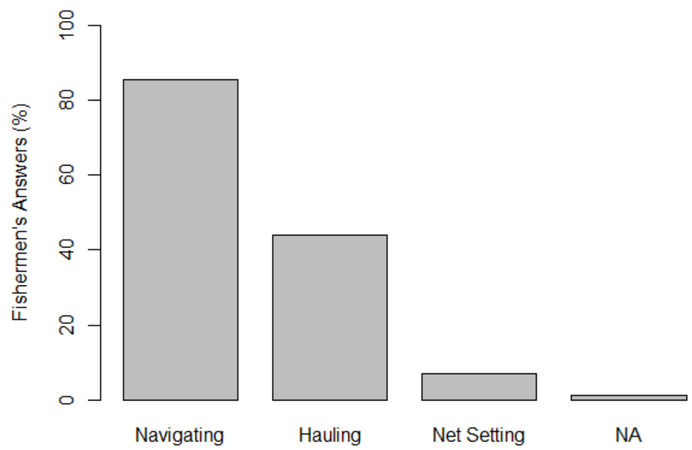


Figure 3.19- Fishermen's answer to the question "In which operation do MPS approach the boat?"

Concerning MPS presence in different operations for each fishing gear type, fishermen who operate purse seiners reported to have MPS approach their boat mainly while hauling their gear (50%; n=4), while 37.5% (n=3) reported that MPS showed up during navigation and only 12.5% (n=1) reported sighting MPS during net setting. For pots and traps, MPS presence is most relevant during navigation (80%; n=20) followed by hauling (20%; n=4). For bottom set nets, presence of MPS was also most reported during navigation (57.1%; n=28), followed by hauling (36.7%; n=18) and only 6.1% (n=3) reported that this happened while net setting. Fishermen operating longlines reported that MPS approach their boats mainly during navigation (60.7%; n=17), followed by hauling (25%; n=7) and net setting

(10.7%; n=3). One of the fishermen who operated longlines did not answer this question, represented in the barplot as “NA” (Figure 3.20).

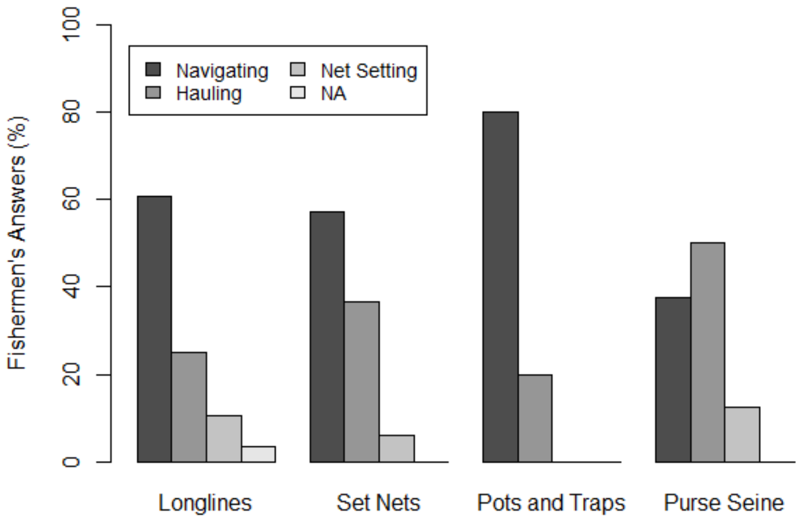


Figure 3.20- Fishermen's answer to the question "In which operation do MPS approach the boat ?” separated by gear operated.

Statistically the chi-square test ($\chi^2(6)$= 6.9423; p=0.3262) showed that the gear operated and operation in which the MPS approach the boats are independent variables, meaning that they do not influence each other.

3.4.2. Most Interactive Species, Damage of Prey (Depredation) and Fishing Gear

Different species tend to interact with different types of fishing gear. In general, regarding cetaceans, the common dolphin (*Delphinus delphis*) is observed to interact the most with purse seiners (100%) and longlines (90%), meanwhile the bottlenose dolphin (*Tursiops truncatus*) was reported mostly for pots and traps (88.2 % of the cases) and bottom set nets 84.8% (Figure 3.21).

Regarding marine bird species, regardless of the gear operated, all fishermen pointed out the yellow-legged gull (*Larus michahellis)* as the species most frequently sighted to interact, followed by the northern gannet (*Morus bassanus*).

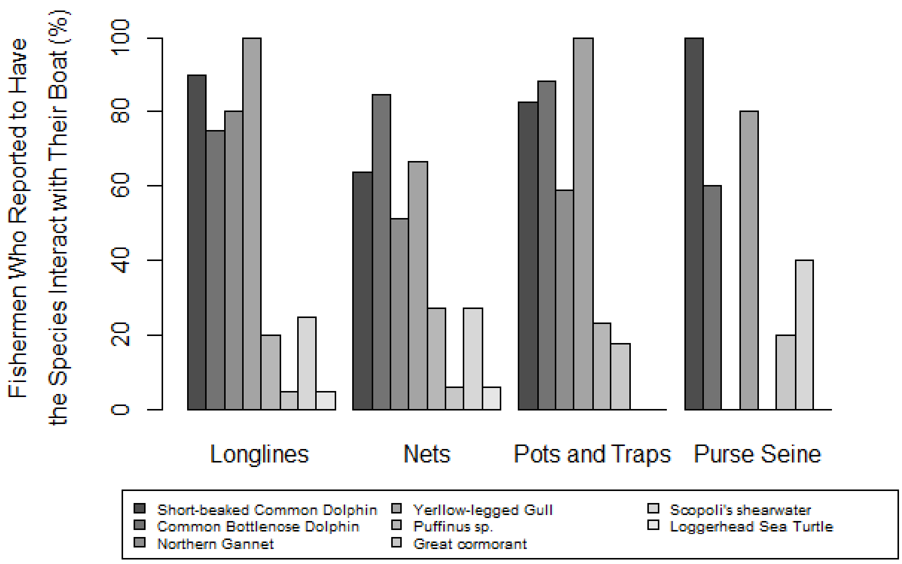


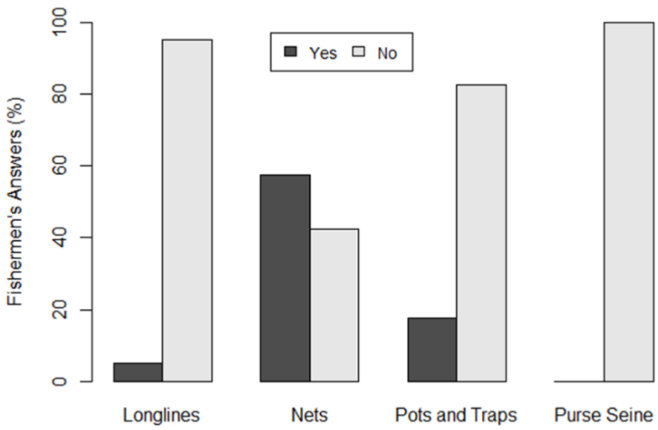
Figure 3.21- Barplot showing the species who, according to the fishermen interviewed, interacted the most with each gear.

Of all the fishermen interviewed, 30.7% (n=23) reported to have problems with cetaceans saying that these species depredated the fish captured and consequently, most of the times, caused damages to their gear. If we separate the answers by gear we can see that the fishermen who reported to have more depredation were the fishermen who operated bottom set nets (gill nets and trammel nets) with 19 fishermen reporting depredation (Figure 3.22a). Regarding the other gears, none of the fishermen who operated purse seine reported to have depredation, 3 fishermen reported that this happened while using pots and traps and only 1 fisherman said that this happened while operating longlines. When asked which species of cetacean caused the problems, 91.3% (n=21) mentioned bottlenose dolphins and 8.7% (n=2) reported to not be able to identify the species.

Only 12% (n=9) of the fishermen interviewed reported to have problems with birds (Figure 3.22b), three of them operated pots and traps, three operated nets and the last three operated longlines. From all the fishermen who reported to have problems with marine birds, 66.7% (n=6) of them reported that they were caused by the northern gannet. Two of the fishermen who operated pots and traps and one who operated nets were not able to identify the species who caused said problems.

None of the fishermen reported to have problems with marine turtles.

a)



b)

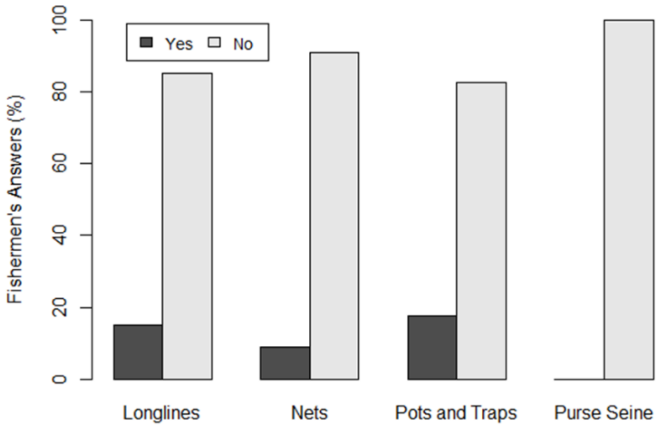


Figure 3.22- Fishermen's answers when asked if there was depredation from: a) cetaceans and b) marine birds.

When asked about substantial loss of fishing gear or species captured, none of the fishermen reported to have substantial loss caused by the MPS studied. The only three fishermen (4%) that reported to have loss of the species captured reported that it was minimal (<5%). Only 3 of the 75 fishermen interviewed (4%) were able to point out the amount of money they lose every year because of cetaceans damaging their gear and the fish captured, the value was between 50 and 1000€, with a mean of 416.7€ (SD= ±510.7€). This equals approximately to 0.3-1.8% of their annual profit (mean±SD= 87 820,5±121 442.5€) (Table 3.6).

Table 3.5- Mean and standard deviation (SD) of the profit and economic loss of the fishermen interviewed by gear operated.

Gear	Profit (€)		Loss (€)	
	N	Mean ± SD	N	Mean ± SD
Longlines	7	44 900 ± 60 430	-	-
Nets	23	79 192 ± 100 101	3	417 ± 511
Pots and T	5	53 356 ± 57 773	-	-
Purse Seir	4	110 300 ± 140 115	-	-
TOTAL	39	87 821 ± 121 443	3	417 ± 511

The MPS reported to have a more negative effect in the fishing activity, mainly because of depredation, were the bottlenose dolphins and the northern gannet. Bottlenoses were pointed by 28% of the fishermen (n=21) as the species who consumed the catch more often, followed by the northern gannet (8% of the fishermen interviewed; n=6), although none of this species consumed more than 5% of the total capture in a year.

3.4.3. Bycatch Reported by Fishing Gear

The fishing gear that reported a higher number of bycaught animals (n=67) was nets (21 cetaceans, 43 marine birds and 3 marine turtles). Followed by purse seiners, reporting 32 animals caught (26 cetaceans, 4 marine birds and 2 marine turtles). The vessels who operated longlines caught 11 animals (1 cetacean, 9 marine birds and 1 marine turtle). The gear with lower incidental capture reported was pots and traps (n=7), that caught in total 7 animals (4 cetaceans, 2 marine birds and one marine turtle) (Figure 3.23).

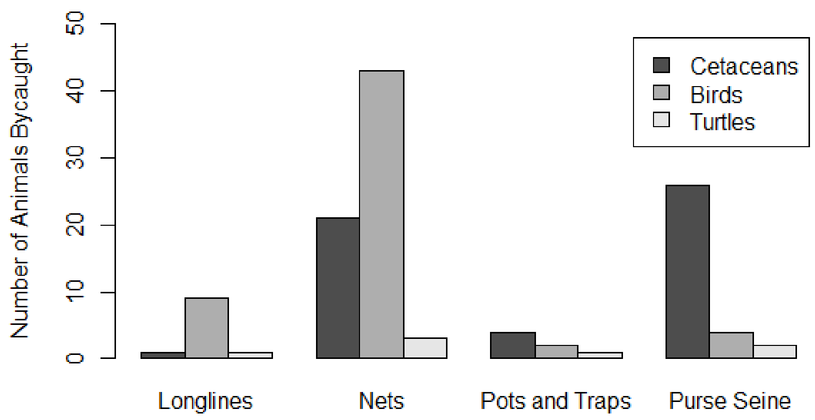


Figure 3.23- Barplot showing the number of animals bycaught per group and gear operated.

The species who showed a higher number of bycatch (Table 3.7) was the northern gannet (*Morus bassanus*) (n=44), followed by the short beaked common dolphin (*Delphinus delphis)* (n=38), and the bottlenose dolphin (*Tursiops truncatus)* (n=14).

Table 3.6- Number of animals bycaught per gears in 2017/beginning of 2018 and respective conservation status.

Species	IUCN status	Number of Animals Bycaught per Gear				Total
		Purse Seine	Pots and Traps	Nets	Longlines	
Short-beaked Common Dolphin	Least Concern	25	4	9	0	38
Common Bottlenose Dolphin	Least Concern	1	0	12	1	14
Nothern Gannet	Least Concern	0	1	38	5	44
Yellow-legged Gull	Least Concern	4	1	0	3	8
Scopoli's Shearwater	Least Concern	0	0	0	1	1
Great Cormorant	Least Concern	0	0	5	0	5
Loggerhead Sea Turtle	Vulnerable	2	1	2	1	6
Leatherback Sea Turtle	Vulnerable	0	0	1	0	1
Total		32	7	67	11	117

Regarding the level of bycatch per trip (Table 3.8), admitting that the purse seine fleet operated four days per week during 6 months of the year and the other fleets operated ≈4 days per week during 10 months of the year, the gear who showed a higher level of bycatch for 2017 in the study area was purse seine that caught 0.0521 common dolphins (*Delphinus delphis*) per trip. This gear also showed bycatch levels for the following species: 0.0021 bottlenose dolphins (*Tursiops truncatus*) per trip, 0.0083 european herring gulls (*Larus michahellis*) per trip and 0.0042 loggerhear sea turtles (*Caretta* caretta) per trip. The gear who followed with the second highest level of bycatch per trip was nets that caught 0.0068 northern gannets (*Morus bassanus*) per trip, 0.0021 bottlenose dolphins per trip, 0.0016 common dolphins per trip, 0.0009 great cormorant (*Phalacrocorax carbo*) per trip, 0.0004 loggerhead turtles per trip and 0.0002 leatherback sea turtles (*Dermochelys coriacea*) per trip, followed by longlines that caught 0.0017 northern gannets per trip, 0.0010 european herring gulls per trip and 0.0003 bottlenose dolphins, Scopoli's shearwater (*Calonectris* diomedea) and loggerhead sea turtles per trip. The gear who showed a lower level of bycatch per trip was pots and traps that caught only 0.0016 common dolphins per trip and 0.0004 northern gannets, european herring gulls and loggerhead turtles per trip.

Table 3.7- Values of the bycatch level per trip and respective standard error by gear operated and species.

Species	Bycatch Level per Trip			
	Purse Seine	Pots and Traps	Nets	Longlines
Short-beaked Common Dolphin	0.0521 (3.7683)	0.0016 (0.1825)	0.0016 (0.0999)	0
Common Bottlenose Dolphin	0.0021 (0.2)	0	0.0021 (0.1618)	0.0003 (0.05)
Nothern Gannet	0	0.0004 (0.0588)	0.0068 (0.6799)	0.0017 (0.1601)
Yellow-legged Gull	0.0083 (0.5831)	0.0004 (0.0588)	0	0.0010 (0.15)
Scopoli's Shearwater	0	0	0	0.0003 (0.05)
Great Cormorant	0	0	0.0009 (0.0883)	0
Loggerhead Sea Turtle	0.0042 (0.2449)	0.0004 (0.0588)	0.0004 (0.0421)	0.0003 (0.05)
Leatherback Sea Turtle	0	0	0.0002 (0.0303)	0

Regarding negative interactions with cetaceans (Figure 3.24a), when comparing the depredation and the bycatch levels (Figure 3.24) we can see that depredation from cetaceans is higher when operating bottom set nets and pots and traps. Meanwhile bycatch is higher for bottom set nets and purse seining. When it comes to interactions with marine birds (Figure 3.24b), although with lower depredation and overall bycatch levels than cetaceans, higher depredation from marine birds was reported by fishermen operating pots and traps and longlines, while bycatch is mostly observed in purse seine, followed by bottom set nets and longlines.

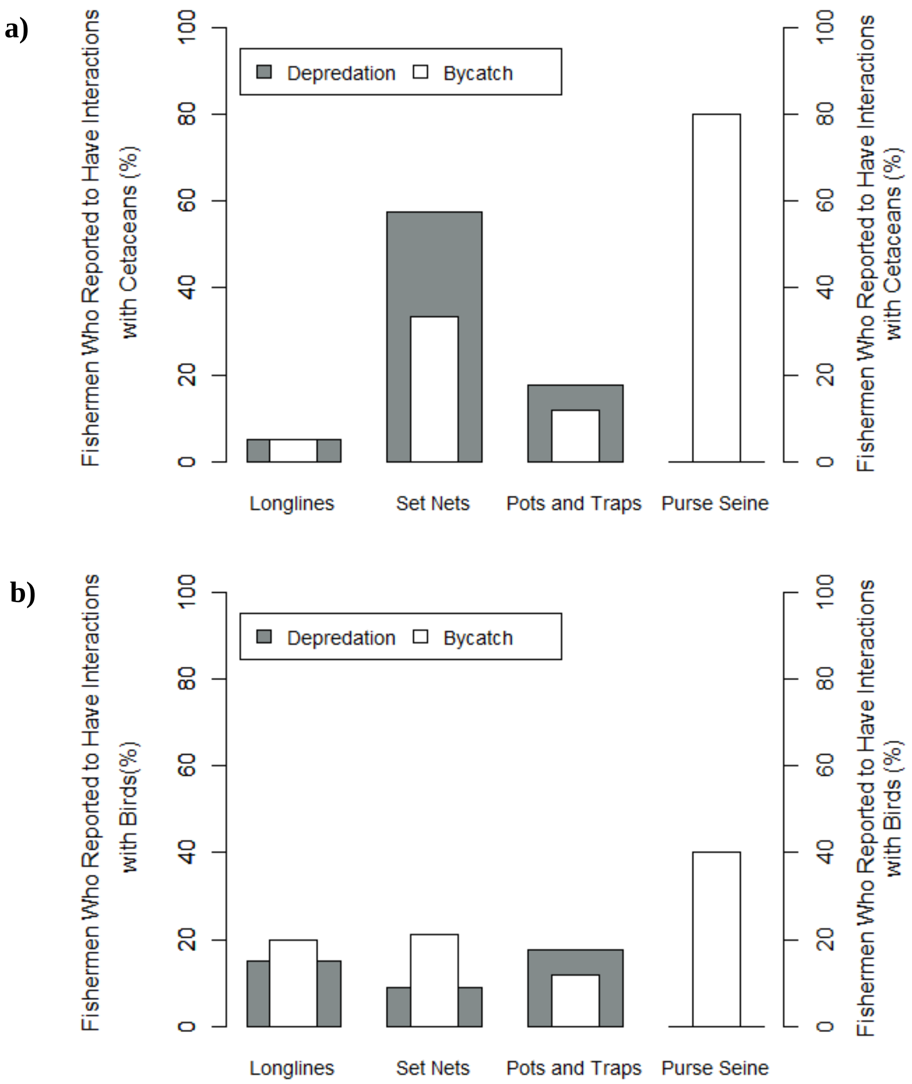


Figure 3.24 – Barplot showing the percentage of fishermen who reported to have interactions with: a) cetaceans and b) marine birds.

3.4.4. Bycatch Levels per Fishing Ground and Depth of Operation

The bycatch events reported by the fishermen interviewed happened mostly when the fishermen were operating near the coast, between 1 and 4 nm. Overlapping the fishing grounds attended by the fishermen who reported to have bycatch we can see that the area between Salema and Alvor shows the highest number of these events (Figure 3.25).

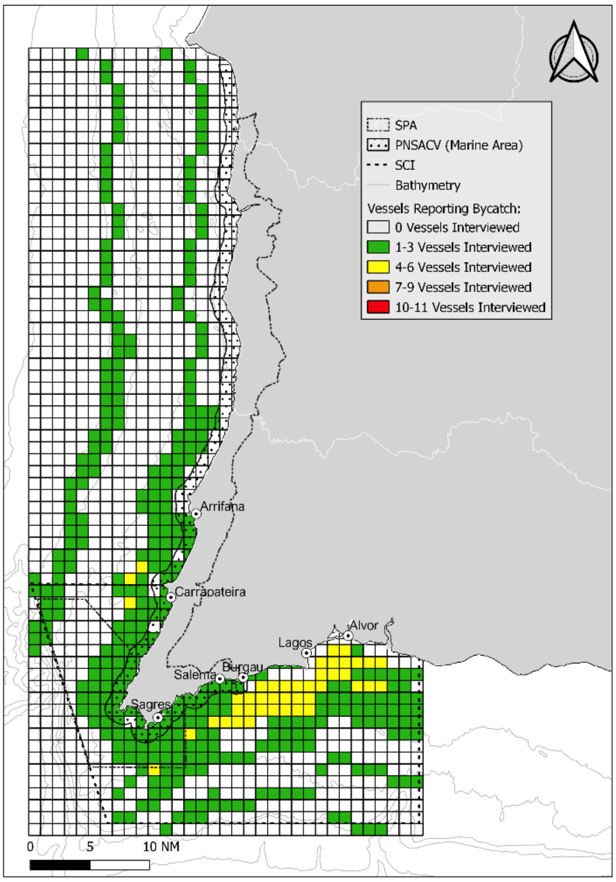


Figure 3.25- Fishing grounds attended by the fishermen who reported bycatch.

If we divide the fishing grounds attended by the fishermen who reported bycatch by the gear operated (Figure 3.26) we can see that when the fishermen are operating longlines the bycatch events happen mostly on the south area of the Natural Park in the area between Burgau and Portimão (the Eastern border of the SCI), between 5 and 7 nm (Figure 3.26a). When operating bottom set nets these events happen on both the South and the Western part of the Natural Park, but mostly between Salema and Portimão (Figure 3.26b). When operating pots and traps these kinds of events happen mostly between Sagres and Alvor between 2 and 4 nm (Figure 3.26c). regarding purse seine, bycatch happens throughout the area attended by the fishermen from Portimão to São Torpes, between 1 and 4 nm, since all the fishermen interviewed that operated purse seine, reported to have bycatch (Figure 3.26d).

a) b) c) d)

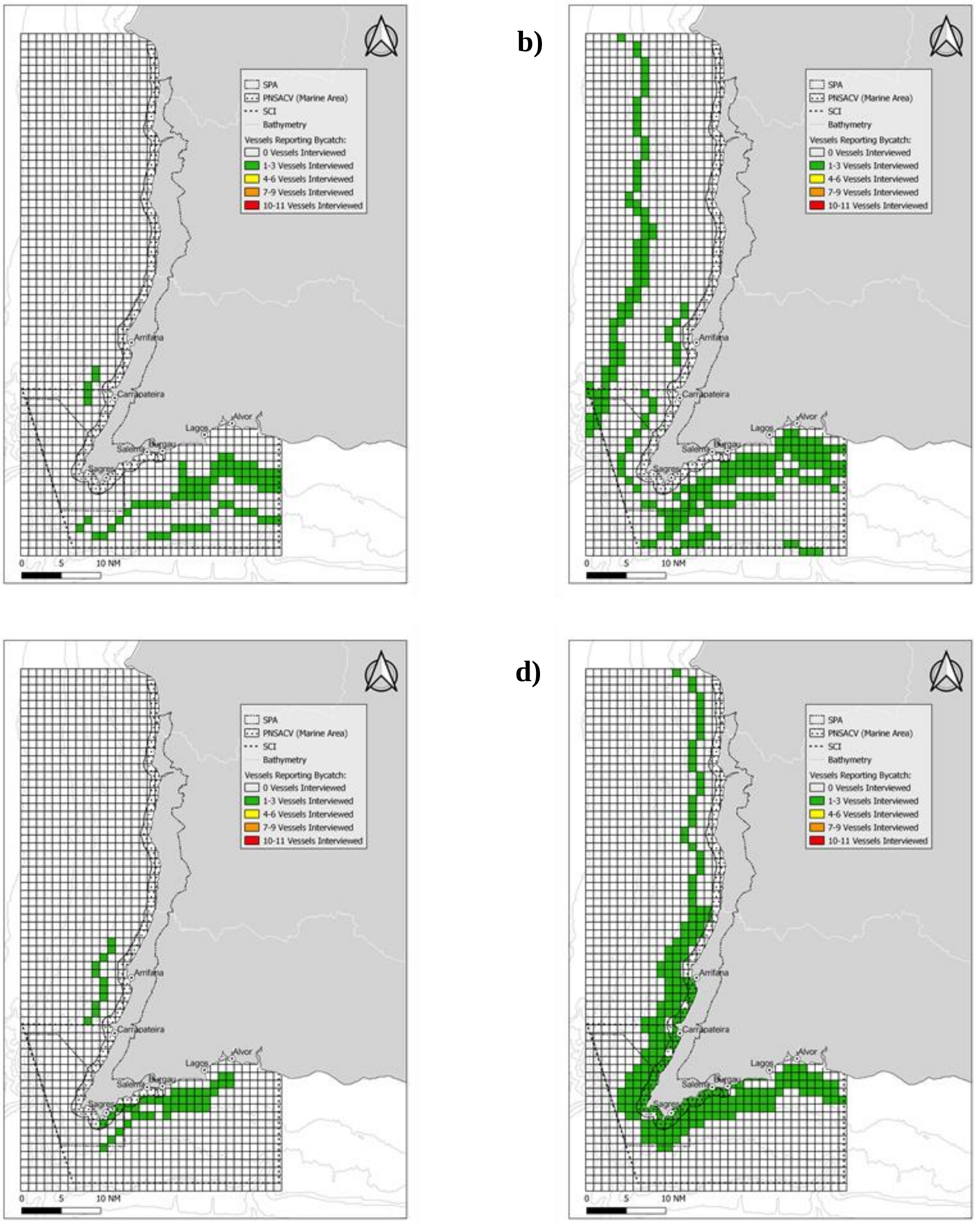


Figure 3.26 – Fishing grounds attended by the fishermen who reported bycatch when operating: a) longlines; b) bottom set nets; c) pots and traps and d) purse seine.

If we compare the fishing grounds frequented by the fishermen who reported bycatch of the different groups of animals studied we can see that bycatch of cetaceans (Figure 3.27 a) happens mostly in the area between Salema and Alvor, when the fishermen are operating at less than 4 nm from the coast. When it comes to marine birds (Figure 3.27 b) there is not a specific area where these events happen more frequently. Meanwhile, when it comes to marine turtles (Figure 3.27 c), fishermen who operate between Burgau and Portimão (the East border of the SCI) had a higher number of bycatch events reported.

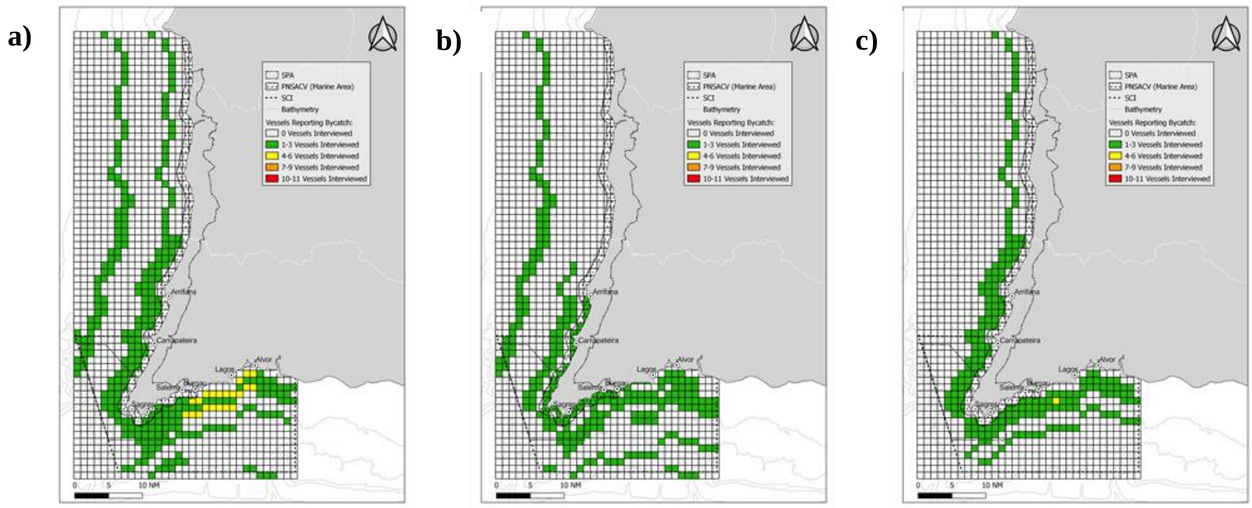


Figure 3.27- Fishing grounds attended by the fishermen who reported bycatch of a) cetaceans; b) marine birds and c) marine turtles.

Regarding the influence that depth of operation has on the bycatch of MPS we can see that, in general, most of the animals are bycaught when the gear is being operated at less than 50m in depth (Figure 3.28), although this does not happen for every gear.

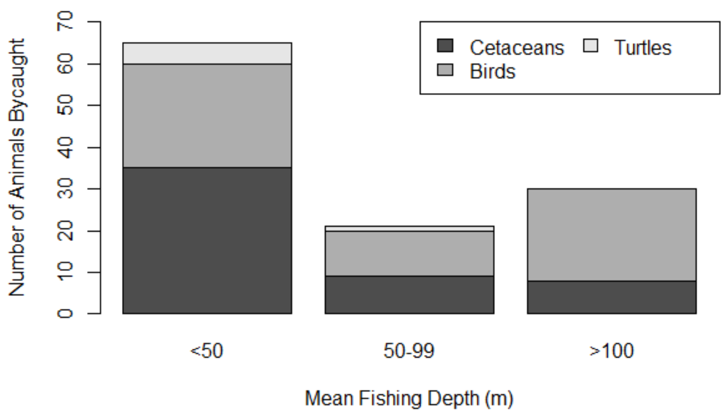


Figure 3.28- Barplot showing the number of animals bycaught per group by depth of operation.

In Figure 3.29 we can see that, in fact, most gears show a higher level of animals bycaught at a lower dept (Figure 3.29a, 3.29c and 3.29d), except when operating bottom set nets (Figure 3.29b), where there is a big portion of animals being bycaught when the fishermen are operating at more than 100m in depth. When analyzing these data it is important to take into account that fishermen using longlines operate at a mean depth of 32.1m, fishermen using bottom set nets tend to operate at a mean depth of 70.9m, fishermen using pots and traps operate at a mean depth of 42.2m and fishermen using purse seiners operate at a mean depth of 35.1m.

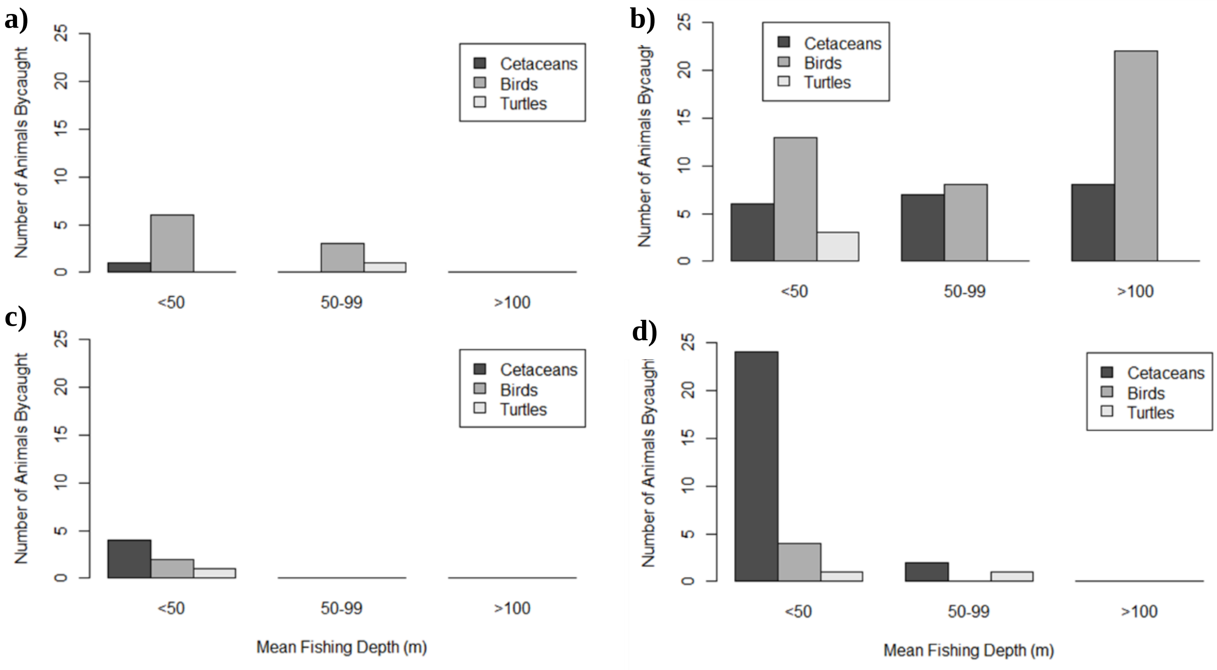


Figure 3.29- Barplots showing the number of animals bycaught per depth when operating: a) longlines; b) bottom set nets; c) pots and traps; and d) purse seine.

3.4.5. Mitigation Measures

Only 14.67% (n=11) of the fishermen interviewed reported to use mitigation measures to avoid the interactions between their gear and the MPS present in their fishing grounds. The rest (n=64) reported to not use any kind of mitigation measure.

Mitigation measures were especially used in long lines, with the method of attaching rocks to the gear so that it sinks faster and does not give time to the bird species to eat the bait. This mitigation measure is used by 9.33% of the fishermen (n=7) interviewed that operated longlines, all of them in the port of Alvor. A small portion of the fishermen interviewed (5.33%, n=4) reported to sail to another fishing ground when they spotted MPS near their vessels. This is also considered a mitigation measure since it minimizes the interactions between the species and the gear. Three fishermen operating purse seine reported also a second mitigation measure for the fishery: not setting the nets if cetaceans were present in the vicinity during school search. If this failed, they would steam to other fishing grounds. One fisherman operating gill nets also reported to wait for the MPS to get away from the boat before dropping the nets to the water in addition to the first mitigation measure.

3.5. Overlap Between Fisheries and the MPS Ecosystem (Whale Watching data)

Data provided by the whale watching company Mar Ilimitado that reflects the sightings of common dolphins and bottlenose dolphins for 2015 to 2018, shows that the common dolphin was more frequently sighted than the bottlenose dolphin, with 1551 and 402 sights respectively for the same period. The distribution of both species in the PNSACV is very wide (Figure 3.30a and 3.31a), being the area between Sagres and Salema the area where both species are sighted more frequently. Although, both species are spotted beyond 10nm, the bottlenose seems to be generally more coastal.

Analyzing the fishing grounds attended by the fishermen operating purse seine (Figure 3.30b), the gear who reported to have more interactions with the common dolphin, and the fishing grounds where the species was sighted (Figure 3.30a), we can see that there is a clear overlap of the fishing grounds attended by the fishermen and the area where common dolphins were spotted.

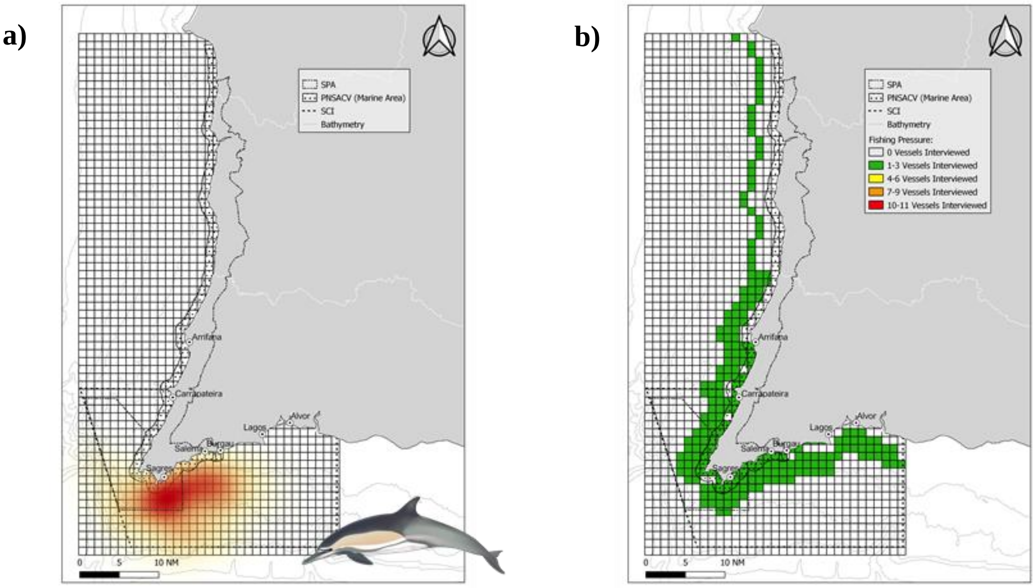


Figure 3.30- a) Heatmap resulting from the data given by the whale watching company Mar Ilimitado resulting from the sightings of common dolphins in 2015-2018; b) Fishing grounds attended by the fishermen operating purse seiners.

In Figure 3.31 we can see the fishing grounds attended by the fishermen operating bottom set nets (Figure 3.31b), gear who reported to have more interactions with the bottlenose dolphin, and the areas where this species was sighted by the whale watching company operating from Sagres (Figure 3.31a). If we overlap both maps, we can see that the there is also a clear overlap between the fishing grounds attended by the fishermen and the ones where bottlenoses where most frequently sighted. However, the area with highest sightings of bottlenoses (close to the port of Sagres) is not the area with more fishing effort, mostly located between Burgau e Lagos.

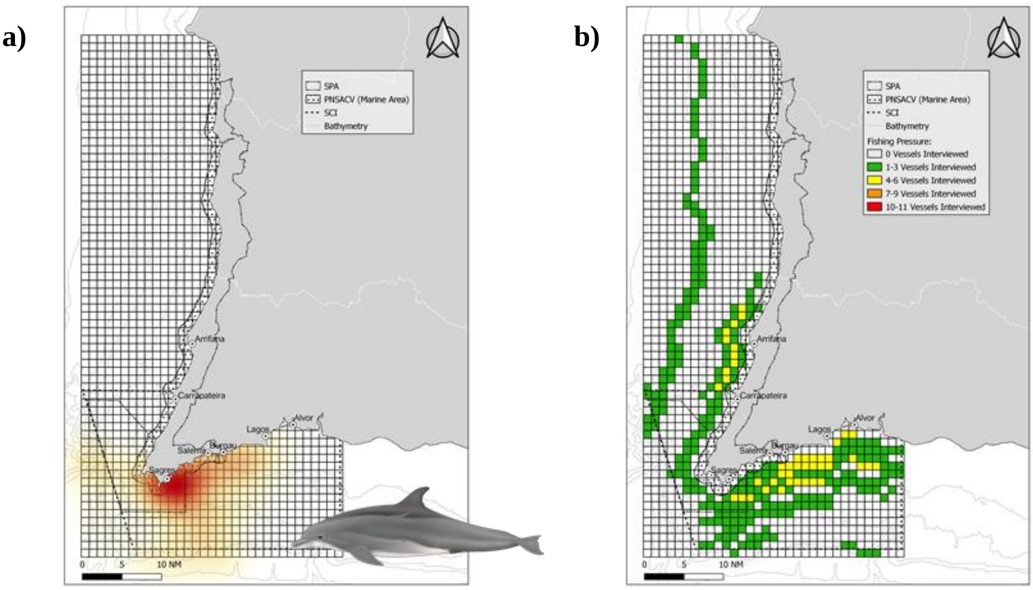


Figure 3.31- a) Heatmap resulting from the data given by the whale watching company Mar Ilimitado resulting from the sightings of bottlenose dolphins in 2015-2018; b) Fishing grounds attended by the fishermen operating bottom set nets.

4. DISCUSSION

Interviews are a cost-effective mechanism for collecting information on the perception and opinion of local fishermen on the presence and interaction between their gear and non-target species. It is important to notice that not all boats operate at the same time of day or time of the year, so a wide time span is needed to collect a large number of interviews (López *et al.*, 2003; Moore *et al.*, 2010; Goetz *et al*., 2014[2]; Revuelta *et al.*, 2018). In this work, although only around 17% (n=75) of the fleet operating inside the PNSACV was interviewed in the 4 months of sampling, most skippers interviewed (n=53) operated small coastal vessels (less than 9m in length). Thus, the dataset provided a good representation of the fleet operating in the area since the Portuguese fishing fleet (> 90%) is composed mainly by local to coastal fisheries (FAO, 2005; Vingada *et al.*, 2011). The fishermen had a mean of 52.4±12.2 years of age and a mean of 32.4±14.6 years of work experience showing that the fishermen's community is mainly composed by middle aged men who started their fishermen activity very young.

4.1. Fishing Pressure

Generally, the south area of the PNSACV seems to have a broader and higher fishing pressure, with some of the fishermen favoring the south coast and operating farther from the coast in comparison with the fishing grounds attended on the west coast of the Natural Park. This might be explained by the difference in sea conditions for both areas. This was a factor pointed out by many fishermen interviewed on the fishing port of Sagres - the most Southwest fishing port considered - when justifying the fact that they tend to attend the fishing grounds in the South instead of operating their gear on the West part of the Natural Park. Generally, there are two areas frequented by a large majority of the fishermen operating in the Park: (1) the area between Burgau and Lagos, in the south; and (2) the area right across the port of Arrifana, in the West coast. When dividing the fishing grounds per gear operated, we can see that the gear that showed a higher fishing pressure throughout the Natural Park was bottom set nets, this is a result of not finding many fishermen operating other gears. From all the fishermen interviewed, 20% reported to operate more than one gear. This gives them the opportunity to adapt their activity to the different times of the year and prey availability. More than half of these fishermen changed between pots and traps and longlines or, in some cases, operated them both at the same time. The polyvalent fleet represents the majority of the active boats in Portugal, operating a great diversity of fishing gears. This represents a problem when trying to make any kind of estimate, since it is very difficult to know the number of boats and the time they are operating one gear. This lack of information makes it hard to estimate the annual fishing effort per gear and consequently almost impossible to improve and extrapolate the bycatch estimates of MPS for the Portuguese fleet (Vingada *et al.,* 2011; Oliveira *et al.,* 2015).

4.2. Sightings of Marine Protected Species (MPS)

Regarding the sighting of MPS in the PNSACV, the group of animals who seem to be more often observed by the fishermen in the area are cetaceans and marine birds, with marine turtles being only occasionally reported. The bottlenose dolphin (*Tursiops truncatus*) was the most frequently reported species, followed by the common dolphin (*Delphinus delphis*). Although the common dolphin is the small cetacean most abundant in the Portuguese continental coast (Wise *et al.*, 2007; Brito *et al.,* 2009; Wise *et al.*, 2018), our result can be explained by the fact that the gear mostly operated, thus most questioned, in the area was bottom set nets usually associated, as reported, with higher interactions with bottlenose dolphins. This association of bottlenoses and bottom set nets, especially gill nets, is due to the fact that the fish species usually targeted by the fishermen operating this type of gear, such as European hake (*Merluccius merluccius*) and Sparidae species (e.g. *Diplodus* sp.) are also the bottlenoses favorite prey (Giménez *et al.*, 2017). This interaction between the bottlenoses and this type of gear has also been reported in other Atlantic areas (Goetz *et al.*, 2014[2]; Fruet *et al.*, 2016; Lyssikatos & Garrison, 2018) and Mediterranean waters (Lauriano *et al.*, 2004; López, 2006; Pennino *et al.*, 2015; Revuelta *et al.*, 2018). For the Portuguese coast, the bottlenose dolphin has been reported as the cetacean species interacting with gill nets especially in the Algarve coast (ICES, 2019). Regarding common dolphins in Portuguese mainland waters, their main prey species is mostly small pelagic fish like the sardine (*Sardina pilchardus*) and the Atlantic chub mackerel (*Scomber colias*) (Marçalo *et al.*, 2018), both also being the main target species of the purse seine fishery. This overlapping of interests is known to increase the chance of interaction between cetaceans and worldwide fisheries. In mainland Portugal this association between the common dolphin and the purse seining fishery has already been well documented and described in some studies (Wise *et al.*, 2007; Marçalo *et al.*, 2015; Wise *et al.*, 2018). Here, this common dolphin-purse seining association is supported by the fact that 100% of the fishermen interviewed who operated purse seiners reported to have interactions with this species. Generally, the two species of cetaceans pointed out by the fishermen as the most frequently sighted are present all throughout the Marine Park, but more frequently in the south area. However, distribution patterns for both species differ. The common dolphin was reported to be seen more frequently on the south-east part of the Natural Park and the bottlenose on the south-western side of the Natural Park.

When it comes to marine birds, the yellow-legged gull (*Larus michahellis*) and the northern gannet (*Morus bassanus*) were the two species more frequently reported by the fishermen, both frequently seen on the west and south areas of the Marine Park. Both species have various fish species in their diet and are opportunistic feeders, benefiting from the fishermen's work to get some food (Lewis *et al.*, 2003; Ceia *et al.*, 2014). Generally, for all gears, the yellow-legged gull was pointed by the fishermen has the species more frequently sighted and the one who would more frequently interact with the fleet operating in the park.

Overall, the target fish species of the different types of gear has a very important role in the associations of a MPS with each gear, and the level of interactions that may occur. The fishermen also pointed out the time of the year as a very important factor that could influence the sighting of MPS, reporting that these animals were seen a lot more frequently in the Spring and Summer. Additionally, fishermen also agreed with the fact that the target fish species was a very important factor in this matter

4.3. Factors Influencing the Fishermen's Opinion

When asked about the cetacean's population trend, most fishermen reported that it increased over the last five years, with the number of interactions being directly proportional. Following SCANS (SCANS II, 2006; SCANS III, 2017), which provide abundance and distribution of cetaceans along European coastal waters, cetacean populations along the Portuguese mainland coast, and namely common dolphins and bottlenose dolphins increased substantially within the ten-year gap between both reports. Although the cetacean population seems to be growing, the fishermen showed a neutral opinion on the presence of these animals pointing out both positive and negative aspects of having these animals present in their fishing grounds. Generally, fishermen who operated bottom set nets showed to have a more negative opinion on the presence of MPS on their fishing grounds. This can be explained by the fact that these fishermen are the ones reporting extra economic loss due to the interactions with these animals. It also shows that the gear operated has some influence on the opinion of fishermen on the presence of MPS. None of the sociodemographic factors (age, work experience and education level) had a significant effect on the fishermen's opinion. Despite that, the effect was negative for the work experience, suggesting that less experienced fishermen might have a slight more positive opinion on the presence of MPS on their fishing grounds. However, considering the number of interviews made and that fishermen with less work experience are also the younger fishermen with a higher level of education, one cannot attribute this effect to a single factor. It is hard to decide between whether this pattern might be induced by the fishermen being younger, and consequently being part of a different generation or simply by the fact that they have less work experience and thus had less time and less interaction episodes with these animals. Although if we look at the frequency of the age distribution, we can see that a new generation of fishermen is arising, marked by the high frequency of fishermen of less than 30 years old compared with the fishermen with 30-40 years old. This can represent a change in the future as typically young people are more open to conservation questions and thus more open to work with scientists to find solutions for the eventual constraints the MPS might represent.

4.4. Interactions (Depredation and Bycatch) and its Implications

Interactions are usually a reciprocal action or influence between two parties. From all the fishermen interviewed, the majority reported to have interactions with cetaceans and marine birds, with more than half (54.7%) of them reporting that these episodes are getting more frequent. These interactions are likely to be causing serious population level effects, especially on groups that have slow reproductive rates and mature late in life like marine turtles and cetaceans (Lewison et al., 2004; Dolman & Brakes, 2018; Revuelta, et al., 2018). Bottom set nets and purse seiners are the gears who reported the highest level of interaction. While most fishermen report that animal groups like cetaceans and marine birds tend to usually be frequent during navigation, some fishermen reported this approach during operations such as set netting and hauling. This approach or presence during fishing operations may have negative outcomes for either the fishermen or the animal. For purse seining the negative effects are reflected in the bycatch of a considerable number of common dolphins. This is supported by the fact that purse seine was the gear who showed a higher level of incidental capture or bycatch per trip for this species. Nonetheless, our data only includes five purse seiners operating in the area and this data is only representative of one year (2017). Hence, although the purse seine fleet generally shows a considerable level of bycatch (Marçalo *et al.*, 2015), we cannot extrapolate our values to the whole fleet operating in Portugal. On the other hand, when operating bottom set nets, the consequences are mainly for the fishermen who report to have depredation from the bottlenoses, this interaction causes the loss of catch and can lead to damages in the fishing gear, thus economic loss. However, bird interaction with each fishery ends up being negative towards the animal side, when entanglement and incidental capture may happen during depredation leading to their mortality, hence bottom set nets showed a higher level of bycatch for marine birds, being the northern gannet, the species most frequently caught by the fishermen operating this type of gear.

All purse seine fishermen reported to try their best to free the animals who got caught in their gear with most of them being freed while still alive, although the probability of the animals surviving can be very low or difficult to evaluate (Hamer *et al.*, 2008; Mannocci *et al.*, 2012). For bottom set-nets, most bycaught animals were already dead when fishermen noticed them in the net during hauling. The South of the Natural Park seems to be the area where most of these episodes happen, but this can be highly influenced by the fact that those are also the fishing grounds which presented the highest fishing effort, as it was the area most frequently attended by the fishermen interviewed. In total, the species who was bycaught more times in the Natural Park was the northern gannet, with forty-four animals being bycaught mostly by the fishermen operating bottom set nets, followed by the common dolphin, with thirty-eight animals of this species being caught, mostly by the purse seine fleet. This output concerning fisheries and MPS species bycaught goes in line with works published previously regarding bycatch in the area (Oliveira *et al.*, 2015; Marçalo *et al.*, 2015)

Even when reporting damaged gear and depredation most of the fishermen were not able to quantify their annual loss, stating that the damage by depredation was minimal (<5%). When asked about the amount of money they lose every year due to damaged gear and depredation most could not point out a value. Only three fishermen, who operated bottom set nets, reported to lose between 50 and 1000€ annually, which equals to about 0.3-1.8% of their annual profit. Most fishermen pointed out that the biggest cause of damaged gear was not the interactions between MPS and their gear, but the entanglement of the gear with bottom debris or other operating or lost gear. This was also a factor pointed out by Bearzi *et al.* (2011) in their study about interactions in Southern Italy.

4.5. Mitigation Measures

Interactions do not seem worrying in the PNSACV for now, nevertheless, it is important to study their implications and consequences. The MPS-fisheries interactions are hard to avoid since there is an overlap between the main prey species of cetaceans and some marine birds, and the main target species of the fishermen and areas exploited. However, it is possible to minimize their impacts with the help of mitigations measures. This would minimize the consequences of the human activities on the populations of MPS and the fishermen's economic loss. The use of pingers or acoustic alarms has been reported by many studies (Hall *et al.*, 2000; Dolman *et al.*, 2016; Edwin *et al.*, 2017) as a very effective way to decrease the levels of interactions and bycatch of cetaceans. These electronic devices produce ultrasounds that keep the cetaceans away from the nets and although the effect of these acoustic signals is still being studied, they generally show effective results for some cetacean species. Also, other measures include the attachment of stimulus panels to the nets to visually warn bycatch prone species to the presence of the gear as suggested by Martin & Crawford (2015). When it comes to birds, Hall *et al.* (2000) suggests the use of streamers to scare them or the use of weights to increase the sinking rate of the gear. This last method is used by the fishermen interviewed on the port of Alvor, that reported to use rocks to increase the sinking rate of their gear, this avoids the interactions when setting the gear, preventing the bait from being eaten by the diving marine birds while the longline is being set. Dolman and Brakes (2018), refers the reduction in fishing effort of some fisheries is the most effective mitigation measure of bycatch and entanglement, when properly enforced and monitored. Mitigation measures are often fishery specific. The results are dependent on positive relationships and collaboration with fishermen. Incentive-based mitigation measures are pointed by Dolman and Brakes (2018) as the most effective to engage fishermen, in an effort to successfully implement bycatch reduction measures from the bottom-up in the hands of fishers. Although, this will require coordinated action between stakeholders and actors to develop changes in fishing practices, fishing effort, gear operated and international agreements to monitor and mitigate bycatch.

Further studies should be done in both areas to acquire more precise data on fishing effort, distribution and abundance of MPS in order to overlap areas prone to higher conflicts. These suggested studies could contribute for better management and conservation measures in these specific problematic areas, while encouraging also the use of some of the mitigation measures stated above or others.

5. CONCLUSIONS

To achieve a well-managed MPA it is fundamental to include all stakeholders in the decision process, taking into consideration all the inputs given to develop a management system accepted by all parties and that can benefit all the stakeholder (Bennet & Dearden, 2014). Although it might be difficult to find a balance between the conservation of the marine environment and the social and economic benefit of its exploitation, it is proven that the protection of certain marine areas can result in better ecosystem services and other benefits for humans (Bearzi, *et al*., 2011). This study provides the fishermen's perspective on the presence and interactions between MPS and their operated fisheries, hopefully allowing the PNSACV managers to take better decisions within the process of managing the Natural Park. It is important to notice that a larger effort is needed to collect additional useful information. In particular, it would be beneficial to conduct more interviews to see the influence of certain factors specially in the interactions. Our dataset was fairly small, none of the GLMs were able to detect any real influence between the factors studied. However, several hypotheses were created, like the influence of the gear operated on the frequency of interactions; the frequency and efficiency of the use of mitigation measures by the fishermen in the PNSACV; the level of interactions (depredation/bycatch) throughout the Natural Park; and the overlap between the area frequented by the MPS and the fishing grounds attended by the fishermen. These could be supported with more data, that would allow improved future testing. A larger number of interviews would give us the chance to get better results in terms of levels of depredation, gear damage and bycatch. According to most fishermen interviewed the interactions in the Park are not worrying since the protected species do not cause large amounts of economic loss. Although, with the apparent increase of the population trend of some of these species (especially cetaceans), and the generalized worldwide decrease of fish resources that could change since there is a clear overlap between the fishing grounds attended by the fishermen and the MPS. Further studies could give us the opportunity to discuss management strategies and ways of reducing the fishermen's loss while also preserving the marine life.

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7. APPENDIX

I – QUESTIONNAIRE

MARSUDOESTE (MARSW) PROJECT

INTERVIEWS FOR THE EVALUATION OF THE INTERACTIONS BETWEEN MARINE PROTECTED SPECIES AND THE COASTAL ARTISANAL FISHERIES IN ALGARVE

Date / / Fishing Port________ ID (Interview No)_____ Name Interviewer __________

Disclaimer:

- All the information collected will be processed and analyzed by CCMAR (Centro de Ciências do Mar) from Universidade do Algarve and by Faculdade de Ciências da Universidade de Lisboa, under the project MARSW;
- All the data will be used solely for scientific purposes;
- All interviews will be kept anonymous and all data will be treated as confidential.

1. What is your function in the vessel?

Shipowner___ Skipper___ Fishermen___ Other___ NA___

2. What gears do you operate? Please point out all the gears used and mark with a * the gear used more frequently.

a) Set Nets
   Bottom Set Nets ___
   Drift Nets ___
   Trammel Nets ___
   Gill Nets ___

b) Purse Seine ___

c) Longlines ___

d) Pots and Traps ___

e) Trawl ___

3. Please fill in with your vessel's characteristics (tonnage, length, horsepower) and the number of crew members.

___ton ___meters ___HP ___ crew members

4. At what depth and distance from the coast do you normally operate your gear? (Please specify the area of operation in the map attached to the questionnaire)

4.1. Distance from the coast
   Max ___
   Min ___
   Mean ___

4.2. Depth of operation
   Max ___
   Min ___
   Mean ___

4.3. Area
   East ___
   West ___

5. At what time do you normally leave for the sea and what time do you get back to the port?

5.1. Time of departure ______________
5.2. Time of arrival ________________

6. Please fill in with the characteristics of the gear operated:

a) Set Nets
   Length ___ Height___ No of nets used___

b) Purse Seine
   Length ___ Height___

c) Longlines
   Length ___ No of hooks used___

d) Pots and Traps
   Length___ No of pots/traps used___

7. Please indicate the target species according to the gear operated.

____

8. How many days a week do you go to the sea (fishing effort)?

____

9. Please fill in with the volume of your annual catch and your annual profit.
9.1. Volume___ 9.2. Profit___ Does not know___ NA___

10. Is the sighting of marine protected species (cetaceans, marine birds and marine turtles) frequent in your fishing grounds?
Yes ___ (Cetaceans/Marine Birds/Marine Turtles)
No___ (Cetaceans/Marine Birds/Marine Turtles)
(If your answer was no, please go straight to question No 32)

11. Indicate the species of marine protected species more frequently sighted in your fishing grounds and the frequency of sighting.

	Frequency of Sighting			Frequency of Sighting			Frequency of Sighting	
Cetaceans	Freq	Rare	**Marine Birds**	Freq	Rare	**Marine Turtles**	Freq	Rare
Common Dolphin			Northern Gannet			Loggerhead Sea Turtle		
Bottlenose Dolphin			Yellow-legged Gull			Leatherback Turtle		
Striped Dolphin			Puffinus sp.			Other		
Harbour Porpoise			Scopoli's Shearwater					
Risso's Dolphin			Other					
Killer Whale								
Other								

12. Do marine protected species approach your boat?
Yes ___ (Cetaceans/Marine Birds/Marine Turtles)
No___ (Cetaceans/Marine Birds/Marine Turtles)
I do not know ___

13. What species of cetaceans approach the boat?

Common Dolphin ___
Bottlenose Dolphin ___
Striped Dolphin ___
Harbour Porpoise ___
Risso’s Dolphin ___
Killer Whale ___
Other ___
None ___

14. In what operation do marine protected species approach or interact with the boat?
Navigation ___ Net Setting ___ I do not know ___
Hauling ___ Other ___

15. What is your opinion on the abundance of the cetaceans population in the last five years on your fishing grounds?
Increased ___ Decreased ___ Stabilized ___ I do not know ___

16. What is your opinion on the presence of cetaceans in your fishing grounds?
Positive ___ Neutral___ Negative ___

a) If you think the presence of cetaceans on the fishing grounds is positive, please mark bellow the reason why.
Help join the fish ___
Help detect the fish ___
Are company ___
I do not know ___
NA ___

b) If you think the presence of cetacean on the fishing grounds is negative, please mark bellow the reason why.
Cause additional expenses ___
Damage the gear ___
Cause depredation ___
Scare the fish ___
Delay the operations ___
Eat most of the fish in the sea ___
Other ___

17. When there are interactions between fisheries and cetaceans there is depredation or damage in the gear?
Yes ___ (Cetaceans/Marine Birds/Marine Turtles)
No___ (Cetaceans/Marine Birds/Marine Turtles)
I do not know ___

a) If yes, please point out which species consume de fish caught or damage the gears:

Cetaceans		**Marine Birds**		**Marine Turtles**	
Common Dolphin		Northern Gannet		Loggerhead Sea Turtle	
Bottlenose Dolphin		Yellow-legged Gull		Leatherback Turtle	
Striped Dolphin		Puffinus sp.		Other	
Harbour Porpoise		Scopoli's Shearwater			
Risso's Dolphin		Other			
Killer Whale					
Other					

18. Can you tell which % of fish caught is depredated annually by marine protected species?
% depredated by cetaceans annually ___
% depredated by marine birds annually ___

19. Is there gear damage during interactions with marine protected species?
Yes ___ (Cetaceans/Marine Birds/Marine Turtles)
No___ (Cetaceans/Marine Birds/Marine Turtles)
I do not know ___

20. Can you estimate the annually economic loss due to gear damage and depredation from marine protected species?

Annual loss due to cetaceans _____€ I cannot tell ___

Annual loss due to other animals ____€ NA ___

21. Have you ever had bycatch of marine protected species?

Yes ___ (Cetaceans/Marine Birds/Marine Turtles)

No___ (Cetaceans/Marine Birds/Marine Turtles)

I do not know ___

a) If yes, please indicate which species and the number of animals bycaught in the last year.

Cetaceans	No	Year	**Marine Birds**	No	Year	**Marine Turtles**	No	Year
Common Dolphin			Northern Gannet			Loggerhead Sea Turtle		
Bottlenose Dolphin			Yellow-legged Gull			Leatherback Turtle		
Striped Dolphin			Puffinus sp.			Other		
Harbour Porpoise			Scopoli's Shearwater					
Risso's Dolphin			Other					
Killer Whale								
Other								

b) If you report to have had bycatch in the last year, please indicate the state of the animal when taken out of the gear:

Dead ___

Alive ___

I do not know ___

c) If you were able to free the animal while still alive, please indicate the % or number of marine protected species freed alive:

___ Cetaceans ___ Marine Birds ___ Marine Turtles

22. In your opinion, the marine protected species freed alive have good possibilities of surviving in the sea?

Yes ___ (Cetaceans/Marine Birds/Marine Turtles)

No___ (Cetaceans/Marine Birds/Marine Turtles)

I do not know ___

22.1. Please justify your answer:____

23. Is there any season of the year or target species which you think attracts the marine protected species and leads to interactions ?

Yes ___ (Cetaceans/Marine Birds/Marine Turtles)

No___ (Cetaceans/Marine Birds/Marine Turtles)

I do not know ___

22.2. If yes, please specify which season/target species____________________________________

24. Do you use any mitigation measure to avoid interactions with marine protected species?

Yes ___

No___

a) If yes, please point out the mitigation measures used and for what group of animals it is.
Sail to another fishing ground ___ (Cetaceans/Marine Birds/Marine Turtles)
Wait for the animals to leave ___ (Cetaceans/Marine Birds/Marine Turtles)
Do not set the gear ___ (Cetaceans/Marine Birds/Marine Turtles)
Pingers ___ (Cetaceans/Marine Birds/Marine Turtles)
Others (please specify) ____
(Cetaceans/Marine Birds/Marine Turtles)

25. In your opinion, what is the tendency of the frequency of interaction during the last five years?
Increased ___ Stabilized ___
Decreased ___ I do not know ___

26. Please identify the five factors that, in your opinion, significantly influences the interactions/bycatch of marine protected species.

Factors	
There is no factors	
Time of day	
Target species	
Fishing grounds attended	
Depth of operation	
Season of the year	
Type of gear/mesh size if operating nets	
Duration of the operation	
Environmental factors	
Others	

27. Do you have any suggestions on how to minimize the interactions between fisheries and marine protected species that you would like to share?
____

SOCIODEMOGRAPHIC DATA

The following information will be used only for validation of the data and results. We recall that all information will be treated confidentially, and this questionnaire will be kept anonymous.

Gender:
Male ___ Female ___

Age___

Residence ________________

Work Experience _____

Household _____

Do you come from a fishermen's family?
Yes___ No___

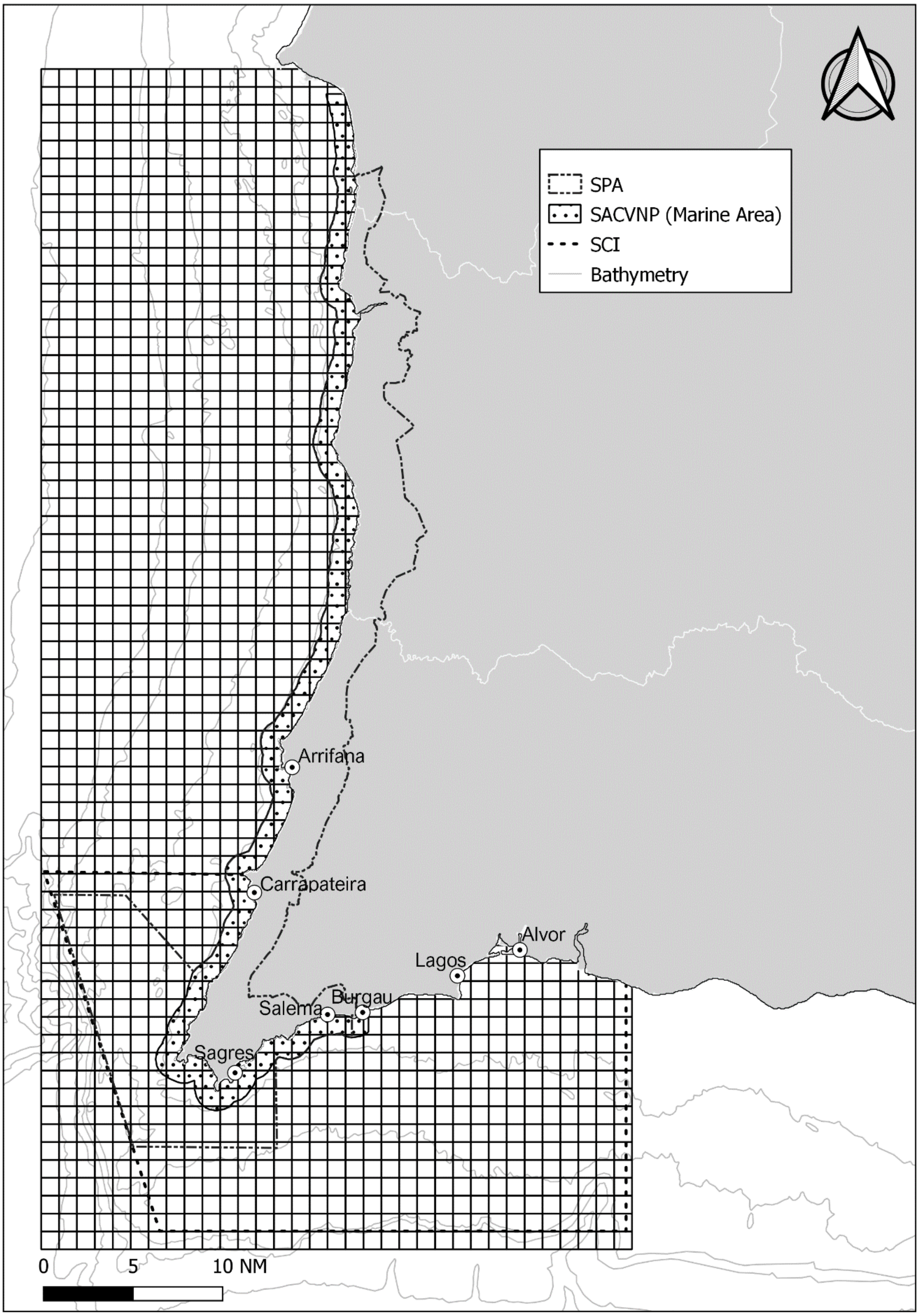
Education Level

1st cycle		Undergraduate degree	
2nd cycle		Postgraduate degree	
3rd cycle		Other (Specify) ____________________	
High School			

Comments/Observations

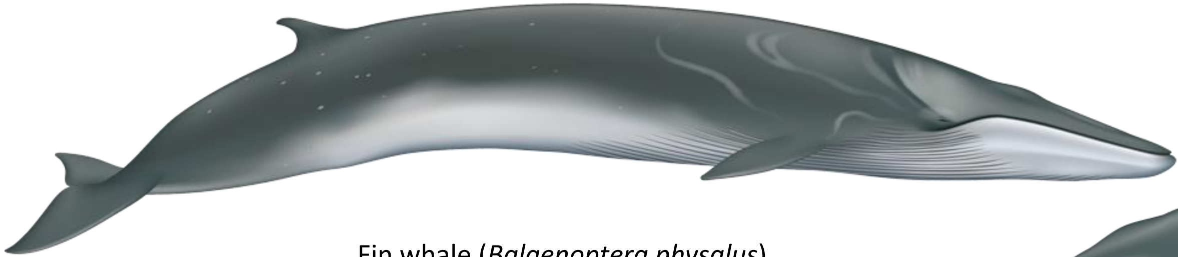
THANK YOU FOR YOUR TIME!

II- PNSACV MAP

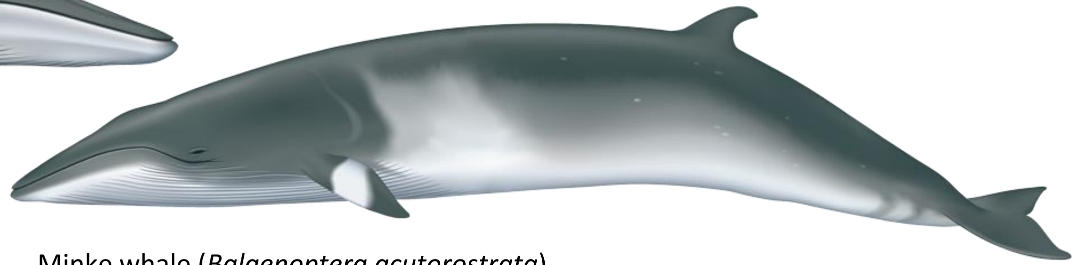


III- IDENTIFICATION SHEET

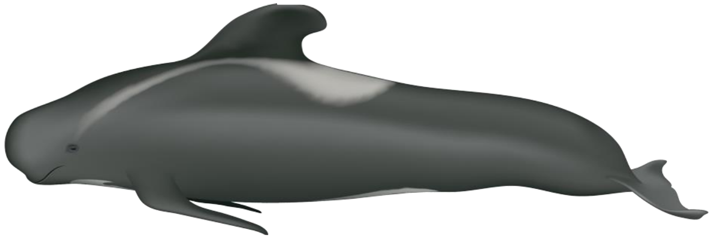
Cetaceans frequently sighted in Algarve



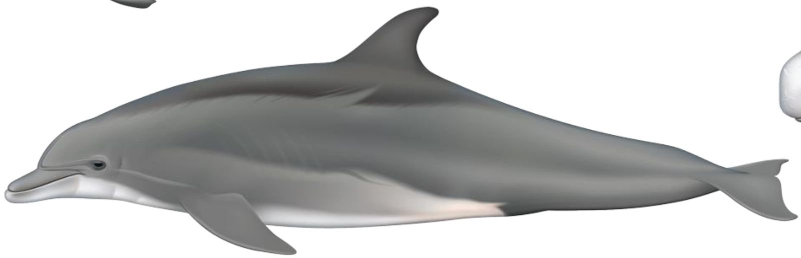
Fin whale (*Balaenoptera physalus*)
Max length = 23m



Minke whale (*Balaenoptera acutorostrata*)
Max length = 10m

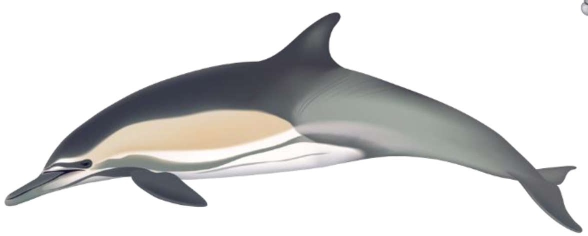


Pilot whale (*Globicephala melas*)
Max length = 6-7m

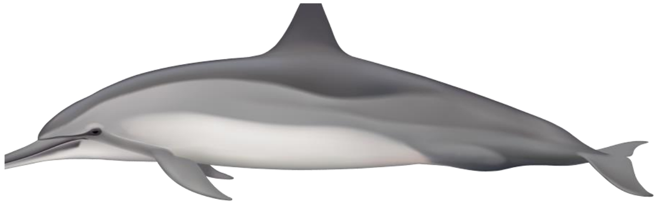


Bottlenose dolphin (*Tursiops truncatus*)
Max length = 3.5-4m

Risso's dolphin (*Grampus griseus*)
Max length = 3.5m



Common dolphin (*Delphinus delphis*)
Max length = 2.5m



Spinner dolphin (*Stenella coeruleoalba*)
Max length =2.5m

Harbor porpoise (*Phocoena phocoena*)
Max length = 2m